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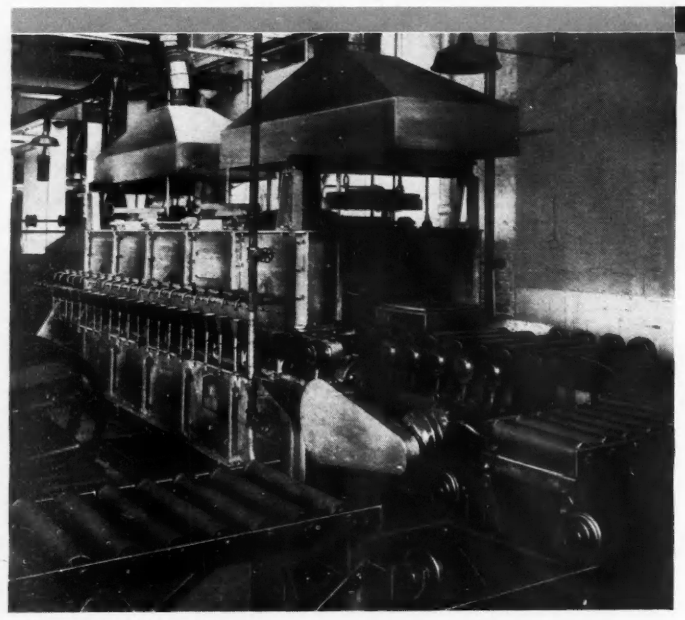

Above—CHARGING END
Below—DISCHARGING END
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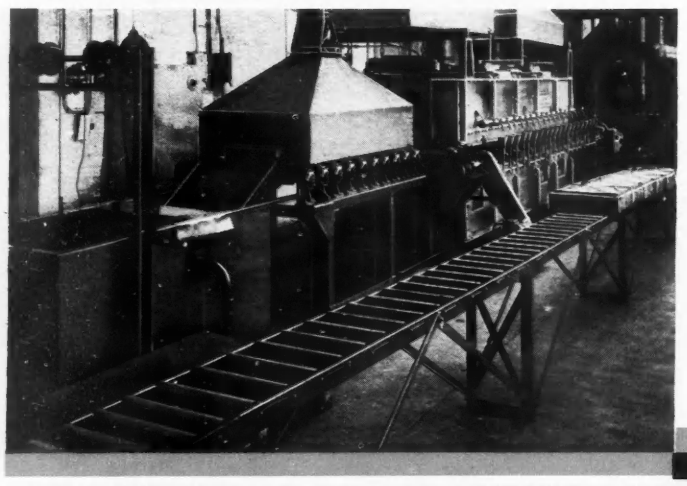

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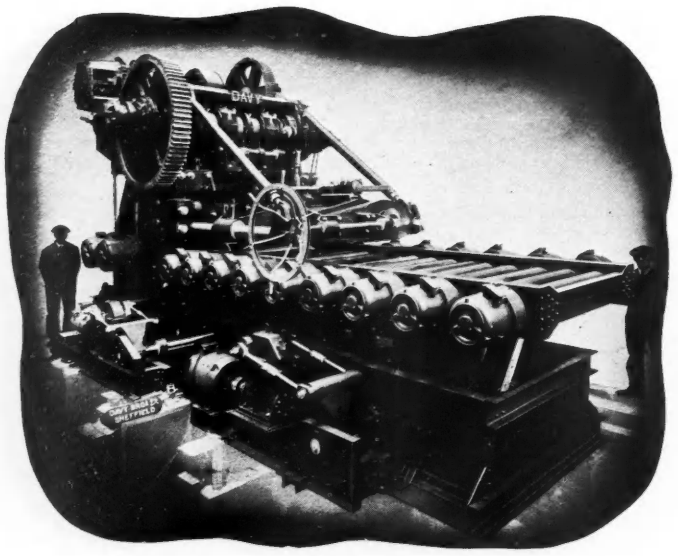

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Restoration of Two Scottish Locomotives.

Two historic Scottish locomotives which were recently withdrawn from active service on the L.M.S. Railway for preservation at St. Rollox Works, Glasgow, have now been restored as far as possible to the original condition in which they first took the road nearly half a century ago. They are an old Caledonian engine, "No. 123," which under L.M.S. number and livery was the last single driving wheel express engine to work in Great Britain, and an old Highland Railway engine "No. 103," the first locomotive to be built in Great Britain, in 1894, of the 4–6–0 wheel arrangement which to-day is one of the most popular types for express service in this country. The Caledonian engine has been painted in its original blue livery, and so as far as possible is exactly as it was when it first left Neilson's Hyde Park Locomotive Works, Glasgow, in 1886. The Highland Railway engine has also been restored to the olive green livery of that company, and has been fitted with its original type of double chimney. This engine, too, was built at a Glasgow works. The officials of the L.M.S. were confronted with a difficult task in the "restoration" of these engines, for during their long and historic careers both underwent slight structural changes, in the course of which some of the original fittings were removed, and these have proved difficult to find. Although they are now "museum pieces," both locomotives have been so preserved as to be capable at any time of working a train, in case they should be wanted when the L.M.S. celebrates its two hundredth birthday (in 2030), or on some other special occasion.

Southend Municipal Aerodrome.

On Wednesday, September 18th, Sir Philip Sassoon, Under-Secretary of State for Air, flew his own aeroplane to the new municipal aerodrome at Southend-on-Sea, which he opened officially. He was escorted by Royal Air Force machines from Eastchurch to Southend. The aerodrome, which had been in partial use as the headquarters of the local flying club, has now been licensed by the Air Ministry for public use. It is in an accessible position about 2 miles from the town, and is well equipped to receive any type of commercial or private plane. The existing flying area is 120 acres, which will ultimately be increased to 200. Runways are provided in all directions 800 yards long. Substantial and roomy hangar accommodation exists with adequate repair facilities. The site was used during the war as a Royal Air Force station, and since its transformation to its present purpose the Corporation has spent some £25,000 on it. At the luncheon held at the aerodrome the Mayor (Mr. A. T. Edwards) expressed the hope that the London and North-Eastern Railway, whose line runs alongside the aerodrome, would provide a station or halt there.

The Government Laboratory.

The report on the Government Laboratory by the Government Chemist for the year ended March 31st has just been published. It shows that the number of samples examined in the course of the year was 522,788, or over 19,000 more than in the year before. The principal increases were those among samples for duty under the Import Duties Act of 1932, and the Safeguarding of Industries Act of the preceding year. Other work was provided by samples taken under various National Marketing Schemes, while oil samples, nearly 17,000 in number, were examined under the regulation for duties on hydrocarbon oils. Other Government Departments and offices utilising the work of the laboratory included the Home Office, the Post Office, the Board of Inland Revenue, and the British Museum. Some 6276 samples of sea water were examined in connection with a scheme of oceanic research carried out by the Fisheries Department of the Ministry of Agriculture and Fisheries and by the Fishery Board for Scotland acting in collaboration with the International Council for the Exploration of the Sea. The water in the Atlantic Ocean being more salt than that in the North Sea, it is possible to trace the drift of water from place to place by making periodic measurements of the salinity at definite positions and charting the results.

National Shipbuilders' Security, Ltd.

The sixth annual general meeting of National Shipbuilders' Security, Ltd., took place at Edinburgh on Thursday, September 19th, when Sir James Lithgow, the chairman of directors, after reviewing the financial position of the company, stated that the past year had been one of the most important in the company's existence, and that further substantial progress had been made in the scheme of the shipbuilding industry to eliminate its surplus capacity in an ordered and equitable manner. He announced that since the last annual general meeting in June, 1934, the purchase of eight yards had been completed, bringing the total number of berths purchased by the company to 149, representing an approximate annual output capacity of over 1,000,000 tons. Two of the shipyards purchased, one on the North-East Coast and one on the Clyde, were being maintained by the company on a care and maintenance basis, while in another case the repairing department had been sold as a going concern and was now being carried on by a new company. Sir James directed special attention to the fact that in view of the improved general condition of the country, greater interest was being taken in the valuable sites with river frontages which the company had available for other industries on the Tyne, Wear, Tees, Humber, Clyde, and elsewhere. Two of the sites on the Tyne had, he said, been disposed of during the year for purposes other than shipbuilding, and active steps were being taken to dispose of the remainder as and when opportunity offered.

The Shipyard Wages Conference.

The Central Board of the Shipbuilding Employers' Federation and executive representatives of all the Shipyard Trade Unions met in Edinburgh on Friday, September 20th, to receive the reply of the Employers' Federation to the application by the Shipyard Workers for an advance of 2d. per hour in wages with an equivalent advance to pieceworkers. After the Conference, which was held in private, Mr. Frank Smith and Mr. Alexander Belch, the secretaries for the workpeople and employers respectively, issued a joint statement, from which we take what follows. In the course of a considered reply, Mr. C. S. Swan, of Newcastle, the employers' chairman, traversed the statements made at the two previous meetings by the operatives in support of their claim, and finally informed the trade union representatives that the existing circumstances and immediate prospects of the shipbuilding and shiprepairing industry were not considered by the employers as justifying any increase in wages at the present time. Hence it would neither be fair to the industry nor to the men to concede an advance at this time. Mr. Westwood, of the Shipwrights' Society and President of the Federation of Engineering and Shipbuilding Trades, spoke on behalf of the unions, and expressed profound disappointment that the shipyard workpeople could not receive some improvement in wages when men in other comparable industries had recently done so. He urged the employers to reconsider the situation, and explained that under constitutional procedure the trades union representatives would report the employers' refusal to their full executives. The Conference was adjourned with no date definitely fixed for the further joint meeting.

Scottish Torpedo Factory Extensions.

The announcement is made that the Argyll Works at Alexandria, Dumbartonshire, have been acquired by Messrs. Turner, Macfarlane and Co., solicitors, of Glasgow, acting for the Admiralty, and that they will be utilised for an extension of the torpedo factory at Fort Matilda, Greenock. The new factory is only two miles from Loch Lomond and 15 miles from the Loch Long torpedo testing range at Arrochar. The works, it may be recalled, were built in 1905 for Argyll Motors, Ltd., and they occupy close upon 6 acres and have a fine block of offices, 600ft. in length. During the war they were used as an ammunition factory and in 1928 were occupied by Scottish Amalgamated Silks, Ltd. The premises still have the lighting and power connections and power shafts ready for belting up the machines which will have to be installed. It will not be possible to open the new works immediately, but it is understood that when they are opened employment for about 1000 men will ultimately be found. At the present time part of the works is being used by the Dumbarton Education Committee as a junior instruction centre, and these activities will be transferred without undue delay to another centre. The news of the sale of the Argyll Works has given considerable satisfaction in the Vale of Leven, where many men have been unemployed since the ammunition factory was closed down after the war.

Welded Steel Bridge.

On Monday, September 23rd, the directors of the Building Centre invited a number of architects and engineers to inspect a new type of welded steel bridge which has been constructed to connect the Bond-street premises of the Building Centre with the new Grafton Galleries extension. The bridge, which has a span of about 40ft., a depth of a little over 7ft., and a width of 10ft. 6in., is of the Vierendeel welded truss type, and is the first of its kind, we are informed, approved by the London County Council for erection in London. The Vierendeel truss principle was adopted as the positions of door openings and the allowable construction heights did not permit a lattice truss or plate girder design. In the new bridge the truss used has no diagonals, and the shear stress usually carried by the diagonal members is transferred to the abutments by the stiffness of the chord and vertical members, and the rigid joints by which they are connected. The bridge is of arc welded construction. The truss members are of H section and are made from flat plates assembled in such a way that they are continuous past the corners where the stress is high. The plates are curved at the corners of the rectangular openings to avoid concentration of stress, and the joints are made only at points of minimum stress. The work of erecting the bridge was begun at midnight on Saturday and continued during Sunday. On Monday a welding demonstration was given and photographs showing welded Vierendeel truss bridges built on the Continent during the last three years for spans between 100ft. to 230ft. were inspected. The bridge above mentioned was designed by Mr. E. F. Needham, and the constructional work was carried out by Sanders and Forster, Ltd., of Barking.

Important Flying Boat Order.

On Monday, September 23rd, Imperial Airways announced that an order had been placed with Short Brothers, Ltd., of Rochester, for a fleet of flying boats, to be used on the main Empire air lines. The machines are to have a speed of close on 200 m.p.h. and a maximum range of flight of about 1500 miles, varying with the specified load and fuel supply. Unlike previous marine aircraft on the Empire routes, which were biplanes, the new machines will be of the unbraced high-wing monoplane type with wing tip floats. They will have a span of 114ft., an overall length of 88½ft., and a height on the beaching chassis of 29½ft. The total loaded weight of each machine will be about 17½ tons, or about 4½ tons greater than that of the largest Imperial Airways plane at present in service, and each machine will have a capacity of 3½ to 5 tons available for passengers, mails, or freight, for normal stage flights. The new flying boats will thus be larger and faster than any aircraft in service on Imperial Airways' routes and will be in advance of any similar craft in the world. While the type of engine to be fitted has yet to be decided, it is known that four will be installed in each machine. The hull design includes an innovation, in that two decks will be incorporated in the fore part. The upper one will accommodate the crew, the mail cargo, and the ship's office; the lower one will take the passengers. It will be recalled that the Government has expressed the hope that by 1937 all first-class mails between this country and Australia and New Zealand will be carried by air.

Road Transport.

In the course of an address to the National Road Transport Conference, which opened on Tuesday, September 24th, at Southport, Brigadier-General Sir A. Osborne Mance discussed the problem of bringing about the best use of the railways and roads in the general interests of the country. He suggested that this end would be most likely attained if the measures adopted were such as to lead to the automatic division of functions between road and rail on a truly economic basis with a minimum of intervention by the State. Unrestricted competition should be rejected, as it would lead to chaos. The question arose as to how far public transport undertakings should be brought into line with the regulation of railways. A wrong transport policy, or a too long period of destructive competition, might well result in such a weakening of transport as would make State interference inevitable. It was, therefore, in the interests of the community, General Mance said, that all forms of transport should be maintained on a healthy basis under the traditional British system of private ownership. In the discussion which followed, the opinion was expressed that it was doubtful whether the 1933 Act would achieve co-ordination, and there seemed to be a widespread feeling at the Conference that little could be expected from co-ordination with the railways under present conditions.

New German Hydrogenation Plants.

According to recent news from Germany, three large hydrogenation plants for the production of synthetic petrol from Ruhr coal will be in operation in the second half of 1936. The two processes to be used are the improved process of Professor Bergius, of the German Dye Trust, and that of Professor Fischer. The former process is to be employed at the Ruhr Prussian State Collieries, where a hydrogenation company under the name of Hydrierwerke Scholven A.G. has been formed. The Fischer process will be employed in a plant to be erected by the Klöckner concern in connection with its collieries at Castrop-Rauxel, and at a plant to be put down by the Ruhrchemie A.G., at Sterkrade-Holten. The cost of erecting these three new plants is estimated at 30 million marks each, and each plant will have a designed annual capacity of about 25,000 tons of synthetic petrol, which will be increased later to 30,000 tons, making a total annual production of 90,000 tons. This figure, it may be pointed out, would not go far to meet the present importation of petrol by Germany of roughly one million tons of motor spirit annually. In addition to the plants above referred to, several plants using the Fischer-Tropsch process are to be erected for the production of petrol from a brown coal basis.

Electric Driving.

No. VI.

(*Concluded from page 286, September 20th.*)

APART from the demand for single-phase motors arising from the existence of a few single-phase distribution systems that were put into service in bygone days, the saving that is sometimes secured by running single-phase lines in rural and other sparsely populated areas has led to the need for these machines in other places. Many domestic appliances are, of course, operated by motors supplied from lighting circuits connected to one phase of a four-wire three-phase distribution system. Small appliances, such as fans, are driven by series motors with laminated poles, suitable for both A.C. and D.C. But there is now also a considerable demand for other single-phase

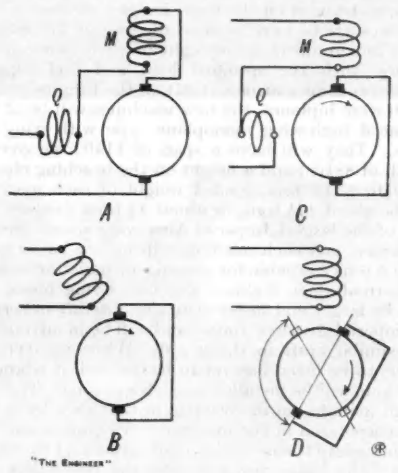


FIG. 55—SERIES AND REPULSION MOTOR CONNECTIONS

motors, such as repulsion, repulsion start, induction, and capacitor motors.

Of the single-phase machines one of the oldest is the repulsion motor, invented by Elihu Thomson in 1887. It is the result of a series of experiments beginning with the repulsion of a metal ring from the end of an A.C. solenoid, although in the repulsion motor the short-circuited armature winding is not repelled out of the field in the same way as the ring, but rotates in it. If the ring used in Elihu Thomson's experiment had been pivoted on a diameter at right angles to the solenoid it would have rotated until co-planar with the solenoid and then remained in that position. Thus the repulsion motor is incorrectly

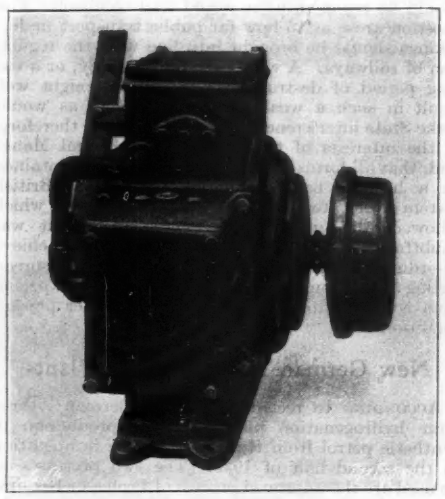


FIG. 56—LOOM MOTOR WITH CLUTCH

named. The difference between the experimental ring and the motor under consideration is that in the latter the moving part is a winding connected to a commutator and short circuited along an axis at some predetermined angle to the A.C. field axis by a pair of electrically connected brushes. Continuous rotation is due to the fact that when it moves in the field its axis is virtually left behind. The characteristics of the repulsion motor are very similar to those of the A.C. single-phase series motor, shown at A in Fig. 55, since its single-phase winding, shown in the diagram B, may be resolved into two components in series, one coaxial with the short-circuited armature winding and the other at right angles to it, as at C. The coaxial component M corresponds to the armature reaction compensating winding of the series motor and the right angle component Q to the field or exciting winding. The only essential difference between the two machines is that whilst in the series motor the armature current is conducted into the armature *viâ* the brushes in the repulsion motor the armature current is set up by transformer action induced by the coaxial component. The stator winding may be wound literally in two components, as shown at C, as proposed by Atkinson and used in certain cases.

Speed variation for a constant-torque load is obtained by moving the brush gear, thus altering the axis of the short circuit relative to the stator winding or, in other words, by altering the relative number of turns between the coaxial and right-angle components of the stator winding. An increase in the number of turns in the right-angle component decreases the speed and at some particular ratio, determined by the brush gear position, the speed becomes zero at full-load torque. In practice the horse-power rating, speed and speed range are correlated and limited by conditions of commutation for a particular design. If a small speed range is required a high h.p. output and high maximum speed are permissible, the number of poles being low and the flux high. But as the speed range is increased both the h.p. output and the maximum speed are reduced at a considerable rate, large speed ranges necessitating a large number of poles with a low flux per pole. Roughly speaking, for the same h.p. output a three-to-one speed range motor costs about 50 per cent. more than a machine with a two-to-one range, owing to the necessary increase in the size of the frame.

Repulsion motors are made by the British Thomson-Houston Company and are suitable for single-phase variable-speed drives when speed fluctuation, with load, as occurs with a D.C. series motor, is not objectionable. On printing presses and similar machines on which each operating cycle is comparatively short, a slight speed fluctuation will not impair the running or the quality of work produced. A handle attached to the brush rocker serves for regulating the speed and a spring-operated hardened steel plunger engaging with a serrated rack on the periphery of the end shield ensures that the speed is maintained at the desired value. Brush gear on relatively large motors may be operated by a hand wheel and a rack and pinion.

These motors have been applied with perfect success to organ blowing. The rise and fall of the air reservoir or main bellows is arranged to operate the lever by means of a cord and tension weight, the speed of the motor being thus regulated according to the demand for wind. Another interesting application is the use of a repulsion motor for driving the vacuum pump operating a cash register system, the brush position being determined at any instant by the degree of vacuum. The motors are also suitable for operating cranes on which both high starting and hoisting torques are required. As in the case of cranes driven by series-wound D.C. motors, light loads are hoisted rapidly and time is thereby saved. Speed control by brush movement avoids waste of power in heating up resistances. Reversal of the direction of rotation can be obtained by brush movement. Prior to starting the brush gear is in the neutral position. It is then moved to one side or the other of this position, as indicated at D in Fig. 55, according to the direction of rotation required. In the diagram the brushes shown "full" indicate the full-speed position for clockwise rotation and those dotted that for counter-clockwise rotation. When the brushes are midway between these positions they are in the neutral or starting position.

Motors which start as repulsion motors and run as induction machines are known as repulsion-start motors. "Century" motors, which operate on this principle, were introduced in this country by the A.S.E.A. Electric Company in 1913 to meet the demand for a high-starting-torque, low-starting-current, single-phase motor of small output, suitable for working on lighting circuits. When the main switch is closed and the stator winding energised, these machines start in accordance with the principle described, but when the armature attains speed a centrifugal governor mechanism short circuits all the commutator segments and lifts the brushes. Thus the motor starts as a repulsion machine, but runs as a single-phase induction motor. It has a series characteristic when starting and shunt characteristics when running, which make it suitable for constant-speed service with frequent starting against more than full-load torque. With the exception of ½ h.p. and ¾ h.p. eight-pole "Century" motors, which develop 300 per

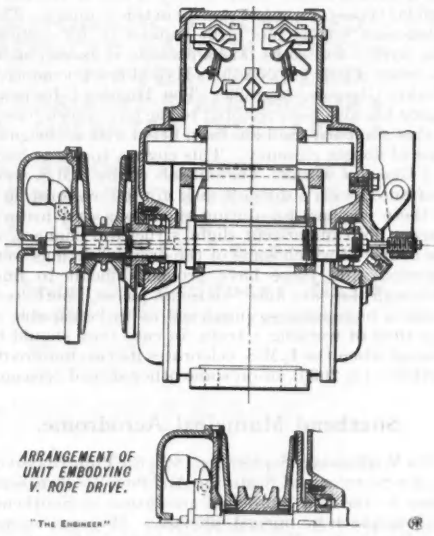


FIG. 57—DETAILS OF LOOM MOTOR

cent. starting torque, motors rated at ⅛ to 2 h.p. are claimed to be capable when thrown direct on to the line by means of a double-pole switch of developing an average initial starting torque of not less than 350 per cent. full-load torque, whilst the momentary starting current does not exceed 260 per cent. of full-load current. Under the same conditions, the average starting torque of 3 to 40 h.p. motors is not less than 300 per cent. of the full-load torque, whilst the momentary starting current does not exceed 260 per cent. of the full-load current. When started with a graduated resistance starter full-load torque can be secured in most cases with a starting current not exceeding 1¼ times the full-load current. Motors of this type have been applied to many industrial duties, and by reason of the relatively small amount of voltage disturbance, they produce when connected to the line they are frequently operated on single-phase lighting circuits. Silent

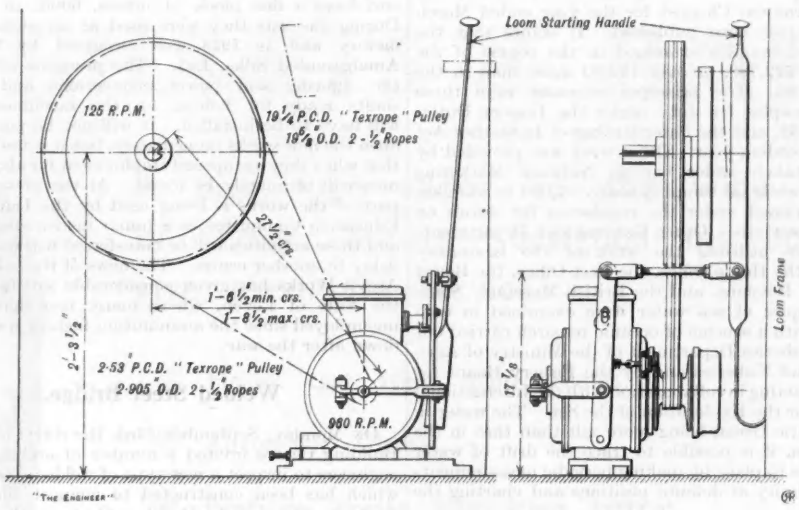


FIG. 58—ARRANGEMENT OF LOOM MOTOR DRIVE

running is a claim made for these motors, which are suited for driving domestic appliances in private houses, blowing church organs, and for many other drives demanding a high starting torque when the supply is single phase.

Higgs Motors, of Witton, Birmingham, have long specialised in the manufacture of repulsion-start motors, all of which are wound for dual voltage, with a series connection for the higher voltage and a parallel connection for the lower voltage. Standard Higgs motors up to 1 h.p. are wound for 100/200 volts, and 115/230 volts, and over 1 h.p. for 200/400

volts, and 230/460 volts. They operate satisfactorily at their rated load, with an increase in voltage of not more than 10 per cent. above these values, but not necessarily within the standard of performance applying to the voltage for which they are designed.

Repulsion motors made by this firm are recommended for driving line shafting, air compressors, pumps of all kinds, washing machines, cream separators, butter-making machinery, and domestic machinery of all descriptions; but they are not put forward for household refrigerators and organ blowing, or for duty involving frequent starting. The armature of the Higgs repulsion motor, which is really a repulsion-squirrel-cage machine, has a double-wound rotor. On the periphery there is a winding similar to that of a D.C. armature, and it is connected to a commutator in the usual way. Below this winding there is a squirrel-cage winding, which, in conjunction with the other winding, develops a high starting torque with a reasonably low starting current. The brushes of this machine, which can

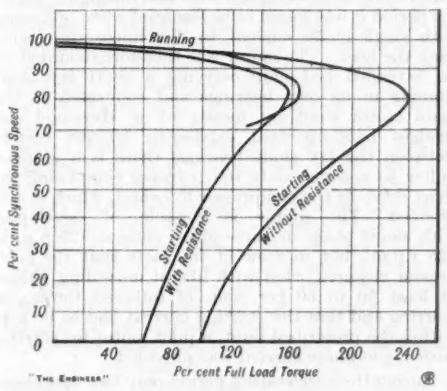


FIG. 59—SPEED TORQUE CURVES OF CAPACITOR MOTOR

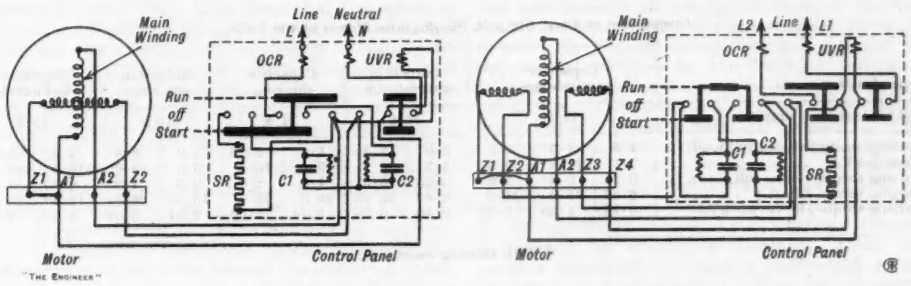
be thrown directly on the line by means of a simple switch, remain permanently on the commutator. Normal machines designed for 50 cycles develop at starting approximately twice full-load torque with approximately three times full-load current, but when wound for 40 cycles the torque may be 10 or 15 per cent. lower.

The production of single-phase, squirrel-cage motors capable of giving a good starting torque has long proved a difficult problem. Many of these machines are, however, employed when a heavy starting torque is unnecessary. Squirrel-cage, single-phase, induction motors made by the English Electric Company, are claimed to have a starting torque with "direct on" starting, practically equal to that of a polyphase machine started with the aid of a star-delta starter. A standard range of these motors has been developed by this company for outputs ranging from ½ to 15 h.p., and larger sizes are offered. They are well suited for drives that do not demand heavy starting duty, or for individual drives if a clutch or loose pulley be used to allow the motor to attain speed before the load is applied.

Practically the only difference between these machines and standard two or three-phase, squirrel-cage motors lies in the method of starting. By virtue of the rotating field produced by the currents in the stator windings, polyphase motors are self-starting, but in the absence of special arrangements the field produced by a simple stator winding on a single-phase motor would be of an oscillating character and the motors would fail to start. To produce similar conditions to those which exist in a polyphase machine it is necessary to provide a single-phase induction motor with an auxiliary starting winding and to supply it with current differing in phase from that in the main winding. Some form of phase-splitting device must be introduced into the circuit during the starting period. Several methods of phase splitting are adopted; some involving the use of condensers. In the English Electric single-phase induction motors the short time rated starting winding is used in conjunction with a resistance. During the starting period the running and starting windings are connected in series, and the external resistance is connected in parallel with the latter. A starter can be supplied which reduces the resistance in several stages before the entire resistance and starting winding are cut out of circuit. Alternatively, a simple starting switch is provided to cut out the starting resistance and starting winding in one step. A feature of the split-phase induction motor supplied by the Fuller and Electrical Manufacturing Company, Ltd., and certain other firms, is that a governor opens a cut-out on the motor when it has attained the normal running speed, and automatically opens the starting winding circuit.

Automatic friction clutches have often been fitted to single and polyphase squirrel-cage motors to enable them to take up the load when the rotor has attained speed. The clutch picks up the load gradually and without shock, either to the motor or the driven machine, and the starting current is reduced. The avoidance of shock is sometimes of considerable importance, and the use of a clutch may be desirable.

A motor combination applicable to the textile industry is made by James Tate and Co., of Victoria Works, East Parade, Bradford. It is for the individual driving of looms and is designed to provide the requisite characteristics. In starting, the loom is accelerated to full speed during the first pick. Since the motor starts against no external mechanical resistance until a speed is reached at which the centrifugal gear engages the clutch and causes the power to be transmitted to the loom, a proper beat of the weft is attained after the shuttle has been safely thrown across. The combination—shown in Figs. 56–58—comprises a totally enclosed motor, a centrifugal clutch, an interlocked switch, declutching mechanism, and tex-

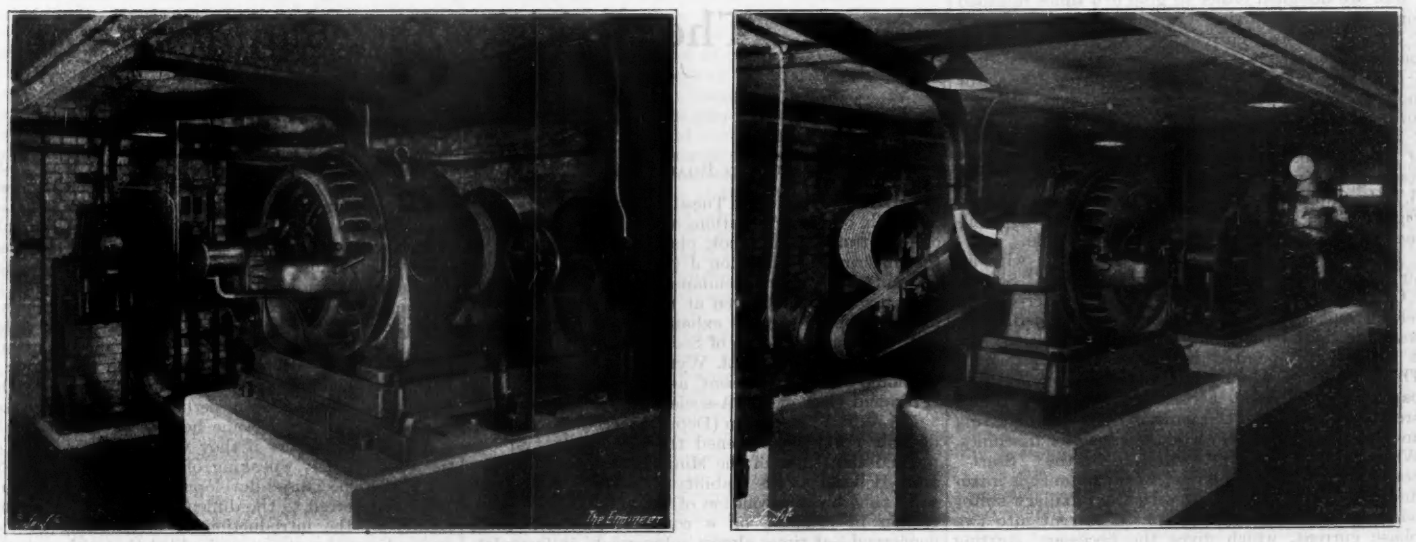


FIGS. 60 AND 61—CONNECTIONS FOR SQUIRREL CAGE CAPACITOR MOTORS

should come to rest in one revolution of the crankshaft. This is effected by the declutching gear connected to the loom handle disengaging the motor from the loom at the precise moment and simultaneously cutting off the current. The severe tests of all individual drives of this kind, known as "banging off," is easily complied with, for since the declutching gear prevents further power being transmitted from the motor at the moment this occurs, the loom is not unduly stressed by being called upon to absorb the power resulting from the sudden arrest of the revolving parts of the motor.

The trouble hitherto experienced with many single-phase squirrel-cage motors was that the starting current considerably exceeded that permitted by supply authorities. While the practice of inserting resistance or reactance or a combination of both in series with the running winding during starting will naturally reduce the trouble, the kVA wasted in this external apparatus can obviously produce no torque. But by regrouping the running winding from series at starting to parallel when running, as in the English Electric Company's "Lo-Ampstart" single-phase squirrel-cage capacitor motor, the current drawn from the line is reduced to about one-quarter of that otherwise needed, whilst all the kVA is retained in the motor for producing torque. The auxiliary winding takes approximately full load current and is displaced about 90 deg. from the running winding current by means of a suitable condenser in the circuit. The net effective motor starting ampère turns are only reduced to half, and the starting current is considerably diminished. A 5 h.p., four-pole, 230-volt, 50-cycle, single-phase "Lo-Ampstart" motor can be started with about 1·6 times full-load current and will develop a starting torque of about 45 per cent. full load torque, which represents a better performance than that obtainable with the average three-phase star-delta started motor. While the starter for these motors is rather more expensive than that required for some other types of single-phase motors, the extra expense may often be justified by the reduction in disturbance which is caused when the motor is switched on to the line.

Single-phase capacitor motors made by the B.T.H. Company as squirrel-cage or slip-ring machines, in sizes from 1 h.p. to 15 h.p. and 30 h.p. respectively,



FIGS. 62 AND 63—SLIP-RING DRIVING MOTOR AND PILOT MOTOR FOR STARTING WITH SINGLE-PHASE CURRENT

rope transmission, instead of the less satisfactory spur gearing. Shock absorption is effected wholly by the automatically controlled centrifugal clutch and no slipping device is required. With the ordinary belt drive a cyclic variation amounting to over 12 per cent. has been recorded, whereas with the Tate drive it was barely 2½ per cent. Once the drive is taken up the clutch is rigid and the impulsive demands for power during one revolution of the loom crankshaft are met by the motor. Waste of power and loss of speed caused by belt slip and stretch are claimed to be eliminated.

In stopping under normal conditions the loom and as fractional horse-power machines ranging from ⅛ h.p. to 1 h.p., are claimed to be exceptionally silent in operation. They have a good efficiency and power factor, and starting torque per kVA. Both during starting and running they give a performance approximating to that of a two-phase induction motor. The control units embody starting and running condensers, which in conjunction with a change-over switch and current limiting device (when necessary), give suitable values of starting torque and starting current and high efficiency and power factor when the machine is running at full speed.

By the appropriate use of condensers a B.T.H.

motor of this kind starts and runs virtually as a two-phase machine, and is claimed to be superior to a motor in which condensers are used for phase splitting during starting and for power factor improvement only when the motor (which runs essentially as a single-phase induction motor) is up to speed. But care must be taken in designing the scheme of connections for the stator windings, switchgear, and condensers to ensure that dangerous voltages to earth do not exist at certain parts of these components, particularly in the case of 400 to 500-volt motors. For this reason the auxiliary winding on 400–500-volt motors is divided and the condenser system is interposed between the two parts, a scheme which limits the highest voltage to earth to a value little more than half that which would exist with an undivided auxiliary winding.

The following table shows the comparative starting performances of B.T.H. 5 h.p., six-pole, single-phase, 400-volt squirrel-cage and slip-ring capacitor motors, those of single-phase, squirrel-cage and slip-ring induction motors, and the repulsion induction motor.

Comparison of 5 h.p. Six-pole, Single-phase Motors at 400 Volts.

Type of motor	Capacitor squirrel-cage.			Induction squirrel-cage.		Capacitor slip-ring.		Induction slip-ring.		Repulsion induction.	
Full load current, amperes	11·8			16·6		11·8		16·2		13·2	
Starting current (times full load)	1·5	2·5	3·5	2·0	3·5	1·5	2·25	1·0	2·0	2·0*	3·5
Starting kVA	7·1	11·8	16·5	13·3	23·2	7·1	10·6	6·5	13·0	10·5	18·4
Starting torque (times full load)	0·25	0·6	1·0	0·25	0·5	1·0	2·0	0·5	1·0	0·75	2·5
Starting torque (lb. ft.)	6·62	15·9	26·5	6·62	13·25	26·5	53·0	13·25	26·5	19·88	66·2
Starting torque, lb. ft. per kVA	0·93	1·35	1·61	0·50	0·58	3·75	5·00	2·04	2·04	1·90	3·60

* With starting resistance.

In making this comparison attention is called by the B.T.H. Company to the desirability of comparing starting kVA instead of starting current in terms of full-load current, since the kVA value is independent of the efficiency and power factor of the motor, which together determine the full-load current. To a great extent the type of single-phase motor employed will, of course, be determined by the starting torque required and the limitations of starting current imposed by the supply undertaking. For small machines for which the starting current is not limited, such as motors up to 1 h.p., either the split-phase, squirrel-cage machine, with an automatic phase-splitting cut-out or a fractional horse-power capacitor motor will be suitable. The former will cost less than the latter, but the choice will also depend on the standard of performance required. When quiet running is essential the capacitor motor is claimed to be superior.

Where strict limitations of starting current are imposed, either the repulsion start induction motor, with a simple rheostatic starter, or the slip-ring capacitor motor can in most cases be used with equally satisfactory results. Up to outputs of about 5 h.p., the repulsion induction motor with a rheostatic starter is generally cheaper than the capacitor motor, but for an output of 5 h.p. and over the capacitor slip-ring motor becomes a formidable competitor. B.T.H. squirrel-cage capacitor motors for outputs up to 1 h.p. are designed either to give 0·6 times full-load torque with a starting current of approximately 2·5 times full-load current or 1 to 1·25 times full-load torque with a starting current not exceeding 3·5 times full-load current. Slip-ring capacitor motors made by this firm either give twice full-load torque with a starting current of approximately 2·25 times full load or any required reduced value of starting torque, with a correspondingly reduced starting current. Typical performance curves of a B.T.H. squirrel-cage capacitor motor are given in Fig. 59. The motors have cast aluminium squirrel-cage rotors, which are virtually indestructible.

For each size of motor a starting panel with an air break drum type starting switch, having "Start," "Off," and "Run" positions, an under-voltage release and two overload relays is provided. The starter cannot be left in the "Start" position, and it cannot be operated in the incorrect sequence. The condensers, which may be of the electrolytic or paper-insulated type, according to size and duty, are also mounted on the panel. Both when starting and running the motors work as capacitor machines. When the change-over switch is in the "Start" position the requisite amount of capacitance is introduced, and in conjunction with the auxiliary stator winding converts the single-phase current into two phase current, which gives the necessary starting torque. When the motor is running at full speed the best performance is obtained by adjusting the current in the auxiliary winding to a suitable value, an operation which is carried out automatically by the starting switch, which when in the "Run" position alters the connections. Diagrams of connections for 240 to 250 and 480 to 600-volt squirrel-cage capacitor motors are shown in Figs. 60 and 61 respectively.

Much has been done within recent years in the way of changing over electrical installations from D.C. to A.C. Small installations of 250–500 kW or under are generally dealt with by replacing all the existing D.C. motors by A.C. machines, but when larger installations that are still good for long service call for consideration it is sometimes found preferable to convert the incoming supply to D.C., with rectifiers, rotary converters, or motor converters. With all the problems involved in the two cases we do not propose to deal, but it is important to note that when the former scheme is adopted power factor correction should not be neglected, for otherwise if the power be paid for on the kVA basis the consumer may easily find that the sum to be met is appreciably more than it was originally.

Static condensers, idle running synchronous condensers, synchronous induction motors, motors with phase advancers or special leading power factor motors, such as the no-lag motor made by the British Thomson-Houston Company, the Kosfi motor made by the English Electric Company, or the Hyposynchronous motor made by Laurence, Scott and Electromotors, Ltd., may be used for this purpose. Perhaps the main disadvantage of static condensers is that it is not possible to regulate the correction in accordance with the load unless several banks are installed with suitable switchgear. While an idle running synchronous condenser, which is really nothing more than a synchronous motor, readily lends itself to power factor control, it is generally cheaper to use a synchronous motor to drive some of the machinery and to correct the power factor as well. One large motor of this type can deal with the wattless current of a number of smaller machines and so raise the power factor of the complete installation.

The synchronous induction motor, which is started as an ordinary slip-ring motor, can be built to start against twice full load torque. An exciter, usually coupled to the motor shaft, builds up its voltage as the machine accelerates, and when it is sufficiently excited the motor pulls into step. By over-exciting the motor it is made to draw a leading current to compensate the lagging currents of other motors. The salient pole synchronous motor, which may also be used for power factor correction, has similar starting characteristics to those of an ordinary squirrel-cage motor, but as when used for power factor correction in addition to providing power, the mechanical output is usually only a fraction of the total rating, the starting torque seldom prevents this type of machine being employed.

Apart from the fact that when works are electrified it is sometimes necessary to take into account the possibility of a change in frequency from 25 or 40 cycles to 50 cycles, electrical contractors may occasionally be called upon to provide for a change from single phase to three phase. An interesting problem of this kind was met with some time ago by the Fuller Electrical and Manufacturing Company, Ltd., whilst acting as sub-contractors to the Lightfoot Refrigeration Company, Ltd., in connection with the installation of refrigeration plant at Edwards Creameries.

The equipment installed consists of a complete brine cooling plant for the elimination of 1,000,000 B.Th.U. per hour for working in conjunction with milk coolers, &c. A Lightfoot horizontal high-speed double-acting compressor running at a speed of 175 r.p.m. and having a balanced crankshaft was installed, and the problem that had to be faced was that of providing it with a motor capable of starting and running with single-phase current at the outset and with three-phase current at a later date. The supply undertakings regulations regarding starting current had to be complied with and during the starting period it was found to be essential when operating with single-phase current to disconnect the motor from the load. The motor was therefore mounted on an extended bed-plate carrying a short lay shaft running in its own bearings and connected to the main motor shaft by means of a Heywood and Bridges hand-operated expanding friction clutch. Between the lay shaft bearings there is a grooved pulley to accommodate ten texropes comprising the short drive to the compressor fly-wheel, which is also grooved. The motor is capable of developing with single-phase or three-phase current 175 h.p. at 725 r.p.m., but in view of the facts that the compressor requires, even with liberal unloading values, at least 50 to 60 per cent. of full-load torque, at starting and that the starting current had to be kept within the prescribed limit, a pilot motor for starting with single-phase current was provided.

During the accelerating period only two operations have to be performed, the correct sequence being ensured by a system of interlocking and pilot lamps. With the main motor, which has a wound slip ring rotor, disconnected from the load, the pilot switch which energises the pilot motor is closed and the main motor is brought up to speed. When a suitable speed for connecting the latter to the line has been attained and has been indicated by a green lamp, the main circuit breaker is closed and the pilot motor is also automatically disconnected from the supply. The main motor is then connected to the load by means of the hand-operated clutch. From the time of closing the pilot motor switch until the other motor has attained full speed the total starting period is approximately 15 seconds, after which the clutch coupling the main motor to the load may be operated. A view of the main motor and clutch is given in Fig. 62, while in Fig. 63 the pilot motor is shown in the foreground. The stator of the main motor naturally has a three-phase winding and one phase serves for single-phase operation.

The British Association.

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(Continued from page 297, September 20th.)

SCIENCE AND ROAD TRAFFIC.

A JOINT discussion on Tuesday morning, September 10th, on the applications of science to the control of road traffic, which took place between Section G (Engineering) and Section J (Psychology), attracted an unusually large attendance, which perhaps was to be expected, and even at the end of three hours did not appear to have exhausted the subject. Mr. J. S. Wilson (President of Section G) took charge of the meeting, but Dr. Ll. Wynn Jones (President of Section J) was also present, as was Sir Josiah Stamp (President-elect of the Association).

Mr. A. T. V. Robinson (Deputy Secretary, Ministry of Transport), who opened the discussion, first expressed the regret of the Minister of Transport, Mr. Hore-Belisha, at his inability to attend, and at the same time his appreciation of the action of the Association in bringing on a common platform those concerned—at times almost submerged—in formulating and administering road traffic policies and those who were studying various aspects of the problem in the more detached atmosphere of the laboratory. Mr. Robinson then dealt with the problem of road traffic in practically all its aspects, and emphasised the need for co-operation between the road engineer, the vehicle engineer, and the psychologist. He drew attention to the physical and financial obstacles in the way of providing roads which might be regarded as ideal from the point of view of providing the greatest safety by removing sharp corners and undesirable junctions; in other words, following the Roman and Napoleonic ideal of the straight line between two points, and, at the same time, providing a road of adequate width. The problem of the type of surface, however, presented difficulties of another character. Were we to aim at a dull dark matt surface or one of a lighter hue? If the latter, were we yet within measurable distance of obtaining satisfactory media which would enable us at a reasonable cost to secure a permanent light surface for the road upon which traffic obstructions of all kinds, whether moving or stationary, would readily show up in silhouette in all weather and lighting conditions? Again, did we envisage within the next few decades light by non-glaring surfaces on all our important roads upon which it would be possible to provide a distinctive and permanent colouration for the pedestrian crossing, and perhaps for other classes of traffic signs which some held to be more readily visible by the driver if they were on the surface of the road itself? Speaking of the traffic signals on roads as a specialised development of railway experience, he referred to the difficulty, and indeed impossibility of the introduction of interlocking devices on road signal systems, and added that although the road driver of the future might hear traffic signals on his car radio set, it was difficult to conceive any automatic control of traffic on the roads. Whilst there was little doubt that there would be much scientific advance in many directions concerning the problem of traffic control and accident, a great deal would undoubtedly continue to depend upon visual perception of signals by drivers and their readiness to respond. After commenting on the greatly improved stability of vehicles, the improvement and ease of operation due to the introduction of simplified gear-changing mechanisms, the higher degree of mechanical reliability, the power-assisted brake and direction indicators as playing their part in facilitating the free movement of traffic on roads, Mr. Robinson referred to the introduction of tests for drivers,

and to the fact that nearly 12 per cent. of the 77,000 drivers who had been examined during the past six months had been rejected for such reasons as defective vision, ignorance of the Highway Code, and inadequate control of the vehicle. He added that he did not propose to forecast any possible future decisions of Ministers of Transport in dealing with the many aspects of the traffic control problem, but pointed to the possibilities of psycho-physical tests as a means of keeping off the roads the demonstrably unfit, and concluded by saying that unless and until science, and not a human driver, assumed control of the vehicle, the occasional error of judgment, the momentary lapse of attention, the states of body and mind which induced neglect of precautions and the taking of risks would continue to result in breakdown of the effective control of road traffic. Nevertheless, the problems of road control admitted of something better than crude empirical methods and certain of their aspects at least deserved the cold and detached consideration of the scientific investigator.

Mr. H. A. Tripp (Assistant Commissioner of Police, Scotland Yard), in a communication read by the Recorder, remarked that although he had been invited to offer suggestions as to the lines upon which scientific or engineering work could help to reduce accidents, whatever he said would represent his personal views only. It was the fact that the vast majority of road casualties were caused through human failure, and whilst the scientist could co-ordinate machinery, he could not co-ordinate human minds. Thus the position was more often than not a subject for the psychologist rather than the engineer or scientist. On all occasions, however, when there was lack of co-ordination of idea or where there was human failure of any sort, the degree of danger was in direct ratio to the speed of the moving object. The swifter the movement the shorter the time interval for protective reaction. Here, then, was the kernel of the matter. In the case of the railways, it was early appreciated that if high speeds were to be attained the tracks must be fenced off from the general public. In the case of motor traffic, however, the position had been reversed. High speeds had been developed first, and only now was provision for safeguarding the tracks beginning to be developed, and in a very gradual fashion. The effect of this inversion of orderly development had been inevitable and automatic—death and injury. That inversion was the root of the whole trouble, and to rectify it was the central problem. Improvements of a very drastic and complete character were required to make the roads of the country as safe as they should be. Mere half improvements were apt to make matters worse. For instance, there was a very narrow, tortuous and difficult piece of roadway in the vicinity of London for which a by-pass had been demanded, but unless that by-pass had duplicate carriageways, separate cycle tracks, good pedestrian pathways, completely signalled junctions, and so on, it was likely that casualties would be increased rather than reduced by the provision of a by-pass. The reason was that the old tortuous road was so dangerous as to be safe, for no class of user dare take any liberties upon it. The position was much the same as regards lighting. From the purely traffic point of view, it was desirable either to have lighting of a very high standard or to have no street lighting at all, leaving the motorist to depend upon his own lights and drive accordingly.

Referring to commercial traffic, the view was expressed that it would be better, from the purely road traffic point of view, that as much traffic as possible should be sent by road to the nearest railway station and conveyed by rail to the nearest point to the ultimate destination, and the road used again for final delivery. If, therefore, engineers and scientists could create machinery, acceptable to all classes of operators, which would enable commodities to be distributed in that manner without re-handling, and get it done more cheaply than by transport throughout by road, they would have made an important contribution to the matter of road safety, for statistics showed that the fewer the road miles the fewer the accidents. There might be complaints at taking the commercial traffic off and leaving the roads more or less solely for the private motorist, but equally, of course, if the private motorist could be diverted to fenced and regulated channels there would be a proportionate saving of casualties. Indeed, the private car and motor cycle presented the most difficult problem of all. The great holiday trek, when motor cars and motor cycles were used for it, simply left a trail of death and injury, and what was science going to do to stop the damage ?

After referring to various directions in which road improvements should be carried out and the provision of underground garages or other accommodation to mitigate the nuisance of the standing vehicle, Mr. Tripp spoke of the importance of anti-dazzle headlights as a matter for the inventor and also of the provision of means of braking, which, whilst preventing skids, would be sufficiently effective to bring about a maximum degree of retardation. He advocated road surfaces which would look white instead of black during rain and at night, but, at the same time, would not be too glaring in sunshine. Further, better non-skid surfaces were required which could be easily and cheaply renewable. In his concluding remarks Mr. Tripp asked the scientist to study the facts at first hand. To a great extent they were common knowledge, and statistical details were to be found in the official reports. For instance, a recent investigation showed that the greatest number of fatal accidents were due to contact between moving vehicles and pedestrians, viz., 56 per cent.; only about 30 per cent. of fatal accidents occurred at junctions; 61 per cent. occurred on straight roads or open bends with a good sight line; 65 per cent. of fatalities were in built-up areas, and so forth. There was little doubt that the most useful results could be produced if the scientist would apply his ingenuity, not to invention, but to the discovery of particular directions in which invention was required.

Mr. G. W. King (technical manager, Dunlop Rubber Company, Ltd.) dealt with the question of control of vehicles as affected by tire design and performance. After pointing out that an analysis of the published figures of road accidents indicated that tire behaviour was a minor factor—confirmed by the experience of the Dunlop Company's own fleet of vehicles over a period in which nearly 3,000,000 miles were run without fatal accident and only five accidents involving personal injury—Mr. King said that tire reactions affecting controllability came under the three heads of braking, acceleration, and cornering. Considerable attention had been paid to methods of measurement of tire efficiency in braking, and it had been found that the factors of major importance governing the behaviour of a vehicle when brakes were applied were speed and " balance " of brakes. The forces involved in acceleration were much smaller than in braking; wheel spin resulting in side-slip was the only thing likely to cause any difficulty. Mr. King also discussed the theoretical considerations relating to cornering, and the results of tests were quoted comparing the effects of new and worn tires on the cornering ability of a car. In general, cornering tests placed different tires in the same order of merit as braking tests, but the differences between tires were shown to be much smaller in the former case. In outlining the necessary qualities of the ideal tire, it was emphasised that a high level of tire efficiency was wasted unless brakes were efficient, and finally attention was called to the danger of using tires that were badly worn, especially when travelling over wet surfaces.

Dr. C. S. Myers, F.R.S. (Principal of the National Institute of Industrial Psychology), remarked that the psychologist's approach to the problems of road accidents was broader than that of most other experts, since he must study all the factors which reacted upon road users and might therefore have some influence on accidents. The statistician, for example, might study the relative volumes of traffic and the relative frequencies of accidents at different speeds in a town in order to determine the most desirable places for the erection of traffic signals. The engineering or other mechanical experts, on the other hand, might be expected to diminish road accidents by increasing the reliability of the engine, brakes, and tires of cars and by improving the surface, breadth and curves of the roads, &c. Psychologists, however, had to study all the factors which reacted upon road users and might therefore have some influence on accidents. Many statistical data appeared to the psychologist as vitiated, if not valueless, because they had been collected and treated without the foresight of pitfalls and without the care in framing questions which would have been employed by one trained in psychological experiment and in psycho-physical methods. Without such training any inquiries which involved the human factor were fraught with danger. So, too, the merely mechanical perfection, say, of car signals and of car controls did not content the psychologist who was unhappy because of their present manifold forms and manifold positions, and he would institute an inquiry into which of those forms and positions best and least satisfied the human requirements of the driver or pedestrian. No such investigation had yet been made, at all events in this country.

Again, whilst recognising the proven value of traffic signals, the psychologist would ascertain their best mode, form, height, &c., also in relation to the human factor. For example, it would be easy to overcome the dangers of defective colour vision among users by instituting differences in shape of the red and green traffic signals, and it appeared worth while to investigate whether the present system of unwarned changes from one colour signal to another was not deserving of improvement. Moreover, there was need to investigate the combined total effect of the various traffic regulations on the driver in view of the danger of their becoming so numerous as to impose excessive strain on his attention by increasing his distraction, and thus to enhance the driver's liability to accident. Road illumination, too, was important, and the psychologist was not content with the desirability of merely increasing its intensity, but would take into expert consideration the dangers of contrast, shadows, glare, and the like, and individual difference in speed of adaptation to sudden gross changes in illumination.

Speaking of penalties attaching to offences against the traffic regulations, Dr. Myers suggested that punishment has less effect than reward, and still less effect than appropriate re-education and the influence of social opinion. Whilst agreeing that punishment for any social offence would not be abandoned under any present conditions, he suggested that it was becoming increasingly recognised that the help of the trained psychologist should be invoked to determine whether or not an offender deserved to be wholly or partly excused from punishment or should receive other forms of treatment.

Dealing with the problem that certain people are more liable to accidents than others, it was pointed out that the Industrial Health Research Board had devised a series of tests which had been uniformly applied to engineers, fitters, plumbers, and carpenters, and also to drivers of certain public vehicles, with the object of eliminating those who were most liable to accidents in their various occupations. Those tests were, generally and broadly, tests of the accuracy and speed of hand-and-eye co-ordination, and the scores obtained from them proved to be closely related to manual and mechanical efficiency. Undoubtedly, the ablest worker sustained the fewest accidents, but it might well be that there really existed in every individual a general susceptibility to the very different kinds of accidents that might occur in widely different occupations. Nevertheless, those who had had the most experience in vocational selection placed a greater reliance on tests which had been devised after a special study of the conditions and requirements of the particular occupation to which they would be applied, and that had been the method adopted by the National Institute of Industrial Psychology in regard to the selection of car drivers. The motor driving tests which had been devised at the Institute assessed separately :—Speed of appropriate reaction to a given signal, resistance to distraction, the ability to attend to several things at once, vision, judgment of size and speed, and, also, self-confidence, road behaviour, and manipulative ability. Although no mental test, whatever its nature, could ever be absolutely infallible, those tests together appeared to afford a sufficiently reliable assessment of driving ability. They did not pretend to determine, however, that a driver who passed them satisfactorily would never be prone to reckless conduct, but it was claimed that they selected those drivers who possessed the necessary abilities to extricate themselves from a dangerous situation when it confronted them; in other words, such tests, when applied to the selection of drivers, did reduce their liability to accident. Similar tests applied to drivers in the Paris bus service had reduced the accidents to those vehicles by 66 per cent. during the period 1929–33, although the number of buses had been increased by 77 per cent., and their speed limit by 44·5 per cent. During the same period the number of accidents to all motor vehicles in Paris increased by 5 per cent. In the Metropolitan Police District of London, between April and the first half of August of this year, the total number of persons killed and injured from all road accidents was reduced only by about 9 per cent., compared with the same period during the previous year, whilst the number of licensed motor vehicles throughout Great Britain increased by about 7 per cent. Even if the application of such selective tests resulted occasionally in the exclusion of good drivers, surely, from the standpoint of the community, it was far better to inflict occasional hardship on the individual than to admit, by our present far less efficient methods of selection, those who would subsequently reveal their unsuitability as drivers by injuring or killing their fellow citizens. If a stringent selection was impossible, and after proper mechanical safeguards had been introduced, then training was the next most important prevention against accidents, and systematic training was essential for all road users. The pedestrian and bicyclist should receive instruction how to avoid accidents from motor traffic, and systematic training was essential for the car driver.

Thus, concluded Dr. Myers, there were many ways in which the special abilities and training of the applied psychologist could be utilised—in the design of traffic and car signals and car controls, in the nature and multiplicity of traffic regulations, in the illumination of roads and vehicles, in incentives, propaganda, and instruction of road users, in inquiries into accidents and defective road conduct, and in the selection and rejection of drivers.

Mr. E. Farmer spoke on accident proneness among motor drivers, and pointed out that it was a relatively stable individual quality that would manifest itself whenever the opportunity was given. It could be detected by (1) psychological or other tests, (2) by examining the previous accident records of the individual. But whilst the former method was not yet sufficiently reliable for general use, the second was reliable if means could be found for making it effective. The motor accident records of the insurance companies could be examined to see how far it was possible from previous records to foretell an individual's accident proneness, and he mentioned that that had been done for a few thousand drivers and positive results obtained. It was suggested that before licences were renewed a certificate from the applicant's insurers should be produced giving his accident record for the previous period.

Sir Josiah Stamp (President-Elect of the Association) suggested that the available accident statistics should be classified under such headings as geographical, personality, age and sex, length of driving experience, length of time of driving in the particular case, mechanical conditions of road and vehicle, time of day, day in the week, month in the year, traffic density, &c. He doubted whether psychological

tests were a good indication of the reactions of a driver to avoid accident. For instance, a lady driver with quick reactions might get low marks in a driving test because of bad gear changing or by handling the vehicle badly, but she might, nevertheless, be better at avoiding an accident than a driver who handled the vehicle more skilfully. He urged the need for those applications of statistical information and refinement that were essential in the discussion of any other scientific problem. For instance, it could not yet be proved that accidents increased with speed because no scientific data were available on that point, and it was necessary to consider whether our present attitude was correct in attempting to obtain a better statistical analysis. The public regarded railway accidents merely in terms of the number of people killed, but he had examined them on an entirely different footing and took into consideration a number of other accidents of which the public knew nothing. The remark by Mr. Tripp that accidents might not be decreased by the construction of a certain by-pass led to the reflection that to introduce safety devices to reduce accidents might be wrong. It might even be that the total number of accidents was a kind of social psychological constant, and as speed, the number of users, and the number of risk-takers increased, so the number of accidents increased.

Dr. Ll. Wynn Jones (President, Section J) referred to some figures given by Mr. King in a table he had shown, indicating a 4 : 1 difference in the minimum stopping distance with the same car on a dry and wet surface. He suggested, however, that that difference might be very much greater as between different drivers.

Mr. E. H. Fryer (Automobile Association) said the question of finance controlled road development, and little progress had been made here since the war for that reason. Unfortunately, successive Governments had more and more controlled the motorist, and thought less of road improvement as a means of preventing accidents. He expressed disappointment that the discussion appeared to have turned upon the control of motorists rather than the provision of better highways.

Mr. Miles expressed doubts as to whether figures of accident proneness were any criterion in the matter of accident prevention, and claimed that much depended upon the type of car and the skill of the driver in handling it.

Dr. Simms complained that many Class A roads are in a very bad condition and contribute to accidents.

Mr. W. H. Gaunt pointed out that without there being dictation from Whitehall, there was need for a more general control of the roads of the country, and the adoption of fundamental principles applicable throughout. For instance, the York–Darlington road contained some portions which were quite unfit because of their excessive smoothness and absence of banking, whilst other portions were as perfect as could be desired at the present time.

Wing-Commander Cave-Browne-Cave (Recorder, Section G) expressed the view that the whole subject of the control of road traffic on scientific principles might be taken up a year hence in a more detailed manner. For that reason he asked for suggestions for topics for discussion.

Mr. Robinson, in a brief reply, said he would report the points raised during the discussion to the Minister of Transport, and in connection with the comment that many accidents were caused by a too liberal use of the motor horn, he said that before that matter could become the basis of regulations as part of traffic control, a quantitative measurement of noise must be established. On the question of lack of uniformity in road surfaces, he recalled that there existed some thousand road authorities throughout the country, and whilst that state of affairs existed it would be impossible to secure the uniformity that was obviously desired.

The discussion then closed. In the afternoon there was a demonstration of skidding and methods for correcting skids, under the direction of Mr. King, who had taken part in the discussion during the morning.

Fundamental Dimensions in Electrical Science.

Whilst the joint discussion on road traffic control was taking place on Tuesday, September 10th, Section G held a separate meeting, at which Sir James Henderson presented a paper on "Fundamental Dimensions in Electrical Science." He pointed out that many suggestions had been proposed during the last thirty years for fixing arbitrarily the dimensions of either μ_o or K_o, the magnetic permeability or electric permittivity of a vacuum, with the object of eliminating the dual system of dimensions for each of the quantities occurring in the science. The object of the paper was to show that if, as was generally admitted, all magnetic phenomena were in fact electro-magnetic, and Ampere's theory of molecular or atomic circuits displaced the two-fluid theory upon which our present treatment of the subject was based, there was no necessity to make an arbitrary choice of the dimensions of either μ_o or K_o, as both were determined, and also to show that Maxwell had forecast this conclusion, if Ampere's theory were finally proved to be the correct one.

It was customary in many text-books, said Sir James, to limit the fundamental equations of the science to particular systems of units, *e.g.*, to c.g.s. electro-magnetic units, &c.; but in studying dimensions it was highly desirable to be able to discuss the problem apart from any particular system of units, more especially units which had been associated for many years with assumed dimensions of μ_o and K_o.

The system introduced in the teaching of dynamics about fifty years ago by Professor William Stroud, which had done so much for the dimensional teaching of all the other branches of physics, provided a means of carrying out this discussion. Fifty years ago it was customary to limit the equations in dynamics to particular units, and Professor Stroud had done a good service in showing that such a limitation was illogical.

Applying that system to the fundamental equations in electrical science, and assuming every symbol contained its own dimensions and particular units, Sir James made comparisons of dimensions of equations, and gave the detailed results of such application. He also compared certain equations upon the assumption that Ampere's theory held, and he quoted extracts from Maxwell's treatise in which Maxwell had expressed his opinion of that theory, commenting that Maxwell's vision in this matter was wonderful.

Our mathematical machinery, concluded Sir James, had become so fine that it penetrated not only the molecule, but also the atom itself, and Ampere's theory of magnetism had become generally adopted by physicists. The combination of that theory with the application to electrical science of Professor William Stroud's system of working in symbols, apart from particular units, showed clearly that the only solution which was typical of the Ampere theory alone led to the disappearance of the whole of the electrostatic system of dimensions, and every quantity in electrical science had its dimensions in terms of M, L, and T alone, and those dimensions agreed with Maxwell's electro-magnetic system. So far as the practical working of the science was concerned, it was indifferent whether we considered the increased magnetic flux in iron as being due to increased permeability or increased electromotive force due to the polarisation of the electronic orbits, and the present method of varying the permeability might be retained, but with the difference that μ_o was a numeric.

Earth Pressures.

Two of the items originally in the programme for Section G (Engineering) on Wednesday, September 11th, viz., noise and electrical terms, were dealt with, on previous days. There was a meeting of the Section, however, at which the Tenth Interim Report of the Committee on Earth Pressures was presented. The work during the year has concerned soil classification and soil mechanics, and was summarised in a note attached to the report. Briefly, it may be said that the work at the Building Research Station at Garstan has been to obtain samples of soil in an undisturbed condition at various depths, and to examine their properties, such as water content, mechanical analysis, plasticity, shrinkage, &c., with the view to classifying them, and also their mechanical properties, such as compression and shear strength. The Committee feels that investigation of this kind is an important step towards the estimation of such properties as the pressure and resistance of soils, which it has set out to try to ascertain, and considers it most important that the work should be carried on, and that either it or some committee of engineers should keep in touch with the work, so as to be fully acquainted with the results. The Committee, therefore, asks to be reappointed.

Inland Water Survey.

The report of the Committee on Inland Water Survey was presented. This was the third report of this Committee, which is presided over by Vice-Admiral Sir H. P. Douglas, the secretary being Captain W. N. McLean. The report traced the history of what has taken place during the lifetime of the Committee, and expressed satisfaction that the Minister of Health had caused to be appointed a Committee to deal with the question of an inland water survey, which had been urged upon the Government by the British Association in conjunction with the Institution of Civil Engineers. Finally, the report stated that although the main purpose of the Committee, as defined in its terms of reference, appeared to have been achieved by the reports of the Committee and the appointment of the Government Committee, nevertheless it was of opinion that valuable work might still be done by a British Association Committee. It was therefore recommended that the present Committee be continued or a new Committee be appointed with fresh terms of reference "to assist generally in promoting research into the inland water resources of the country, and in particular into underground water supply and river flow." It was pointed out by Captain McLean that the Government Committee had not yet reported, but definite progress was being made and an Inspector of Inland Water Survey for England and Wales had been appointed.

(To be continued.)

The Shipping, Engineering and Machinery Exhibition at Olympia.

No. III.

(Continued from page 300, September 20th.)

August's, Ltd.

THE principal exhibit on the stand of August's, Ltd., Halifax, England, is the foundry sand-conditioning plant illustrated in Fig. 20, which has a capacity of from 4 to 5 tons of facing sand per hour, or 2 tons of loam; but there is also a laboratory-sized machine in operation. The drawing which we reproduce in Fig. 21 represents a standard plant of this type with practically all the gear above the floor level, as at Olympia, but it will be readily appreciated that the design is adaptable to local conditions, and it may sometimes be more convenient to sink some of the parts in a pit.

As will be seen the plant consists of two separate sections—a sand-cleaning plant, including a rotary screen, dust and silt-removal unit, a magnetic separator, an elevator, and a storage hopper, combined with a sand-mixing and aerating section, consisting

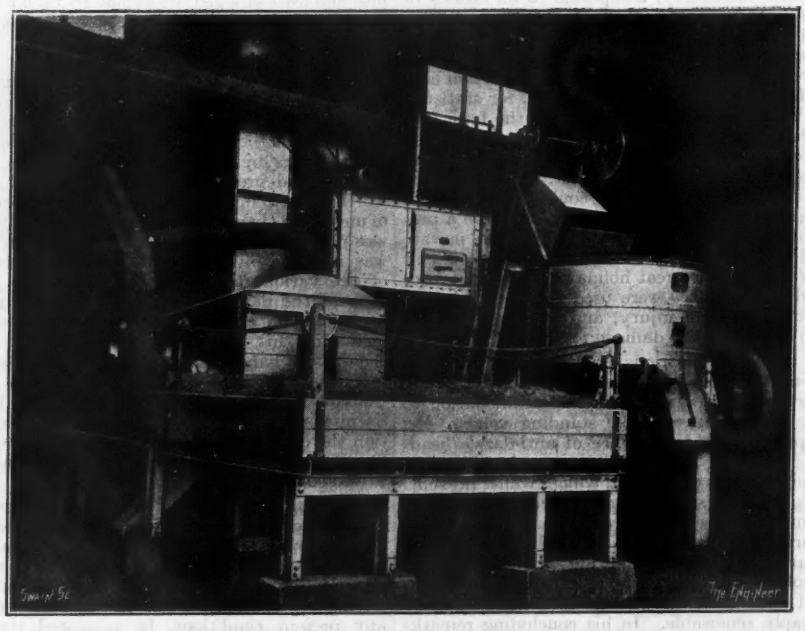


FIG. 20—FOUNDRY SAND CONDITIONING PLANT—AUGUST'S

of a robust bucket loader, an August's Simpson intensive foundry sand mixer, and an August's aerator. Either of these two sections can be worked independently according to the work in hand. The routine of work in the foundry determines whether it is advantageous to work both sections of the plant together, or one part at a time. It may, for instance, be the practice in the foundry for facing sand to be delivered to the moulders during the earlier part of the day, and for the mould to be knocked out during the later part of the day, in which case, of course, the mixing section will be in operation during the morning, the cleaning section in operation during the afternoon. On the other hand, where the practice of the foundry is to cast both morning and afternoon, then the whole of the sand plant will be in use during the whole day.

Considering, first, the cleaning plant, it will be noticed that the used foundry sand is discharged at floor level into the inlet of the rotary screen. This sand, after screening, falls on to a belt conveyor which carries the screened sand over a magnetic pulley, and thence into the boot of an elevator feeding the used sand into the storage hopper. At the screen all dust and silt is extracted from the sand by an exhausting system and is recovered at the discharge of the exhausting cyclone for easy transport to the refuse tip. The sand arriving at the storage hopper is screened, cooled, free of any foreign matter, free of iron, and free of dust and silt. It will also be noted that the processing of this sand, from the point at which it is discharged from the rotary screen, is continuous and automatic.

The mixing section of the plant consists of a No. 2 size August's Simpson intensive sand mixer, together with an inclined track-type bucket loader and an August's by-pass aerator. The bucket of the bucket loader is positioned beneath the discharge gate of the used sand storage hopper. The aerator discharges at a point so high above floor level as to permit of the placing beneath of wheel barrows or discharge bins. This section of the plant is operated by the workman raising the door of the storage hopper and allowing the necessary quantity of cleaned, old foundry sand to fall in the bucket of the bucket loader. The necessary quantity of new sand and coal dust is added to the used sand already in the bucket. The bucket is then elevated, discharging its contents into the mixer. Water is added in the mixer during the mixing operation by means of a water pipe and spray. After the mixing operation the door in the floor of the pan of the mixer is opened, permitting the mixed sand to be discharged directly on to the aerator, and from thence directly into the wheel barrow or other receptacle. The aerator permits mixed sand which does not require aerating to pass directly into the receptacle without aeration. It will be gathered that the mixing is done in batches and the alteration of the mixture by varying the percentage of new sand and coal dust is made by hand at the bucket loader, thus permitting a quick and simple alteration of sand mixtures as and when required. The labour involved in operating the plant is a minimum, as one man should be able to run the plant to give the output required. If a peak output of the plant is required, the addition of a labourer charging the screen with used sand would be all that would be necessary. The power consumption of the plant also is very low; in fact, only four motors are needed, and the total nominal horse-power of these is less than 24.

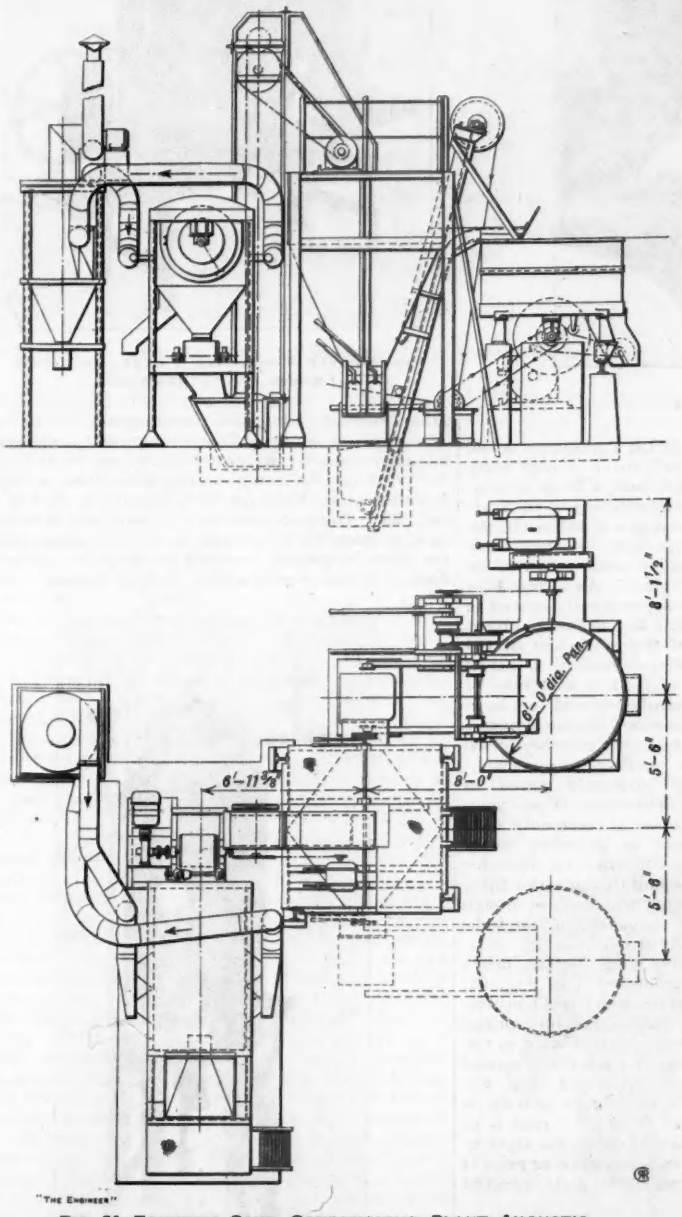


FIG. 21—FOUNDRY SAND CONDITIONING PLANT—AUGUST'S

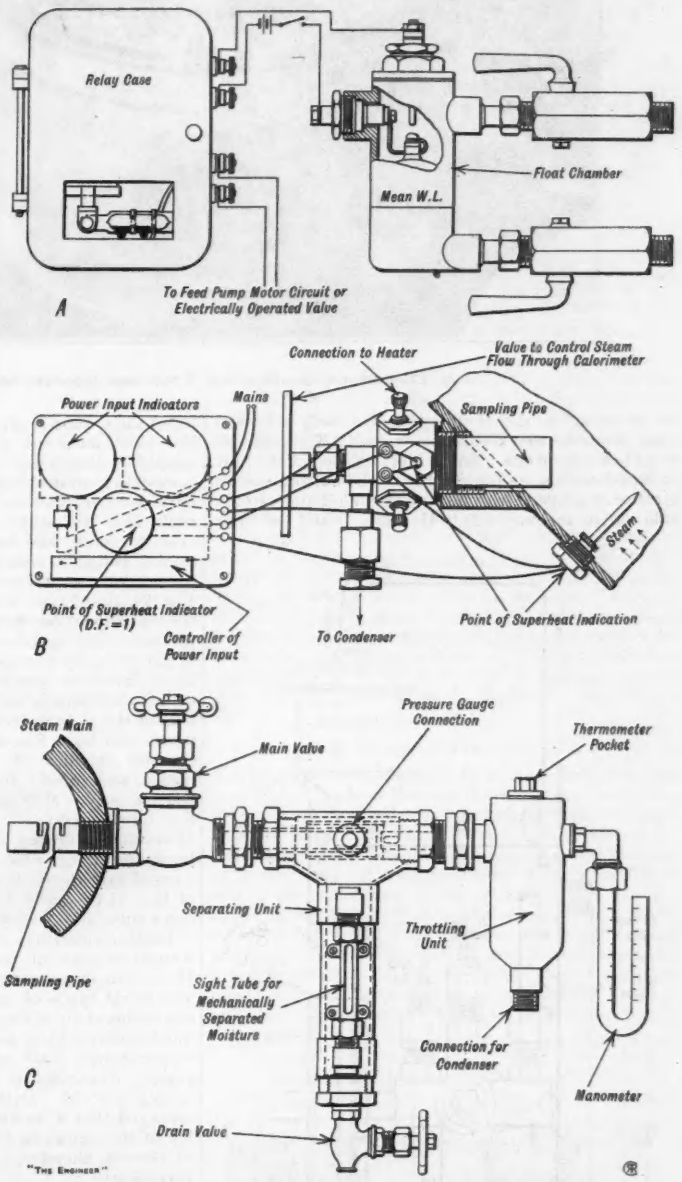


FIG. 22—FEED WATER REGULATOR, STEAM DRYNESS CALORIMETER AND SEPARATING AND THROTTLING CALORIMETER—DOBBIE, McINNES

DOBBIE, McINNES AND CLYDE, LTD.

There are a number of new devices to be seen on the stand taken by Dobbie, McInnes and Clyde, Ltd., of Glasgow, and several of them are illustrated by engravings on this page. The boiler feed-water regulator—Fig. 22 A—is a remarkably compact affair. It consists of a small cylindrical float chamber connected through cocks to the boiler. By the raising of the water level in the boiler the float is caused to rise until the electrical contact it carries "makes" with another contact in the top of the float chamber. By this means a circuit is made to a solenoid in the relay case which may be mounted in any suitable position in the boiler room or elsewhere. The action of the solenoid is to draw up a rod and thereby to tilt a lever upon which there is mounted a mercury switch. In this manner the electrical circuit to the feed pump is broken and the motor shut down. Obviously, as the water level in the boiler falls, the float in the float chamber will eventually break contact in the circuit to the solenoid, with the result that the solenoid rod will drop and the mercury switch be swung over to the contacts closed position, thereby restarting the feed pump motor.

In Fig. 22 B there is shown the new electric steam-dryness calorimeter, just developed by the firm. Like the feed-water regulator, this apparatus, too, is remarkable for its compact dimensions, which are, indeed, so small that errors attributable to heat radiation are negligible. It will be seen that a valve is provided to regulate the flow of steam through the device to a condenser at which the rate of flow is measured directly by weighing the condensate. Included in the pipe line before the regulating valve is reached, there are two electrical devices, a heater, and a pyrometer. The principle employed is that of heating the small amount of steam passing through the apparatus until it is "dry," and measuring the power necessary to effect this purpose. It will be recalled that on a T φ diagram the latent heat of steam at any pressure is represented by a horizontal line of constant temperature lying between the saturated steam and water lines. As soon as the steam begins to be superheated, its temperature begins to rise. Thereby an accurate and easy method of determining the point of saturation is provided. In the instrument under discussion, the temperature of the steam in the sampling pipe is measured by a thermo-couple, which is electrically linked in opposition to a thermo-couple in the apparatus, through an indicator meter. In operation, the observer slowly increases the flow of current through the heater coils of the apparatus until there is a movement of the "superheat" indicator. Then the readings of volts and ampères in the heater circuit provide a measure of the dryness of the steam. Calculation is rendered unnecessary by the provision of a table with the instrument converting the readings directly into terms of dryness.

The new separating and throttling calorimeter—Fig. 22 C—shows considerable improvement over earlier types. It has been considerably reduced in size to give a smaller surface area, so that less lagging is

required to reduce the effects of radiation. It is, in addition, so designed that during the mechanical moisture-separating process the steam is caused to double back upon itself twice, and therefore provides its own jacket.

Those who visited the Exhibition two years ago will no doubt remember the "Teledep" indicator for showing the depth of liquid in a tank placed at some distance from the indicator itself. The principle is quite a simple one. An air bell is placed in the tank of liquid as close as practicable to the bottom and its interior connected through an air-filled pipe to one side of a mercury-filled U tube, fixed at any suitable point above or below or to one side of the tank. The other leg of the U tube is either open to atmosphere or, if the tank is under pressure, is connected to its top. By means of a hand pump having characteristics in common with the bicycle variety, air is pumped into the air bell until all the liquid is expelled. Then, clearly, the pressure of the air within the bell is that due to the head of liquid in the tank above the lower edge of the bell. This pressure acts upon the mercury in the U tube, so that the differential height of the mercury in the two legs is a measure of the quantity or weight of liquid in the tank. Actually, since the amount of mercury is, of course, constant in volume, only one leg of the U tube is exposed against a graduated scale. For most purposes, this arrangement proved quite suitable. But where the tank had a large area in comparison to its height, the movements of the mercury were so small for large changes of volume in the tank that the scale markings were uncomfortably close together, and had even, in some cases, to be read through a magnifying glass. As a result of considerable experiment, the apparatus illustrated in Fig. 24 has been developed. It has for its object the magnification directly of the movement of the mercury. On examination of the drawing, it will be found that the mercury is enclosed in a U tube of large diameter, which communicates with an indicator tube of much smaller diameter. On the indicator side of the U tube there floats on the mercury an oil which has been found to be unaffected appreciably by the vapours of liquids commonly stored in tanks, and which has no deleterious effect upon the mercury. Moreover, this oil is commonly used for lubricating purposes and is therefore easily obtainable. Owing to the difference in diameter between the leg of the U tube and the indicator tube, a small movement of the mercury will displace enough of the oil to produce a large movement in the indicator tube, thus magnifying the scale.

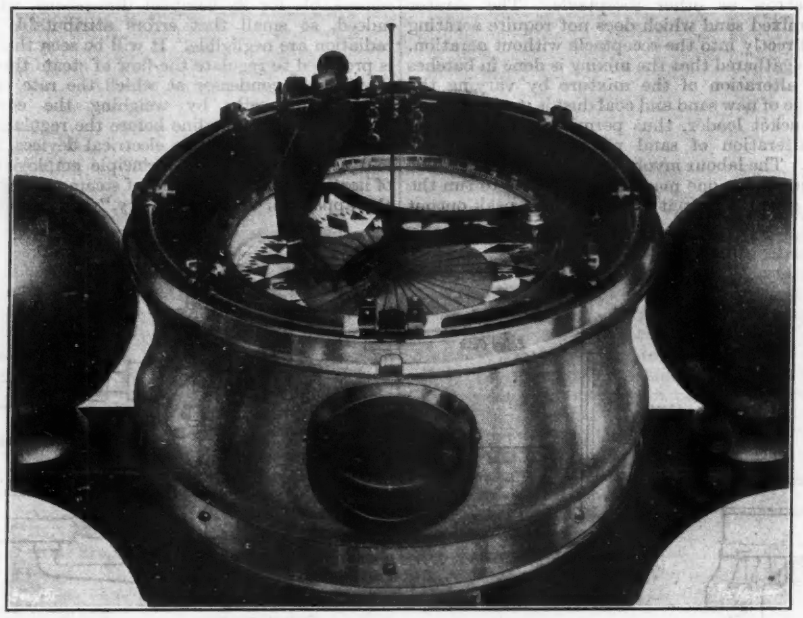


FIG. 23—TORQUE SUSPENSION COMPASS—DOBBIE, McINNES

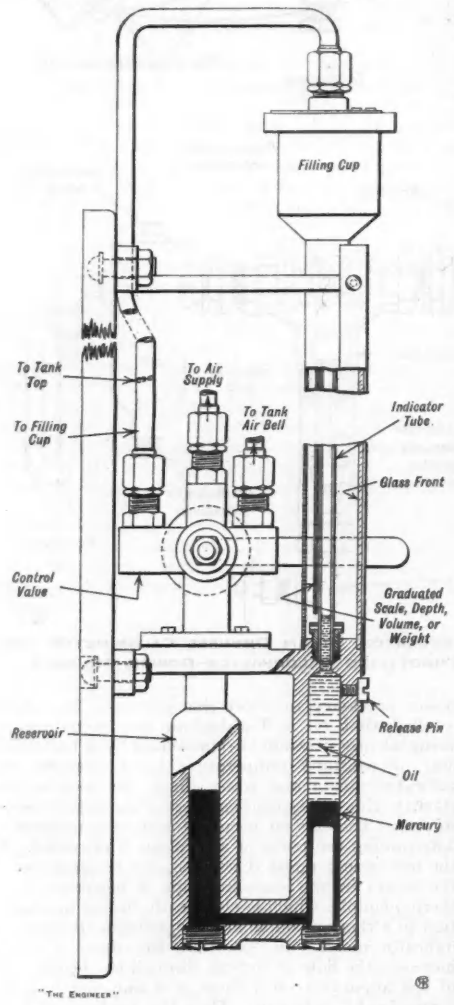


FIG. 24—"TELEDEP" INDICATOR—DOBBIE, McINNES

Lastly, reference should be made to the firm's torque suspension compass, illustrated in Fig. 23. It is of the dry card type, and has two novel features. The usual types of spiral or leaf suspension springs are replaced by a ring of wire, clearly visible in the illustration, subject to torsion. To meet any special circumstances that may arise on board ship, the period of oscillation of this suspension system is arranged to be variable. The "torque" ring is so arranged that if oscillation should occur, the tightening of the screws to be seen in the engraving grips it in sleeves, thereby, of course, altering its inherent periodicity.

THE STREAM-LINE FILTER COMPANY, LTD.

Two new applications of the filter, made by the Stream-Line Filter Company, Ltd., of 45, Horseferry-road, London, are shown in Figs. 25 and 26. As will be recalled, filtering is accomplished by passing the oil through packs of filter paper, the packs being kept in compression by springs. The solids present, even colloidal carbon, remain on the outside of the packs, only clean oil passing through. The oil is warmed to assist the flow, which is maintained by the alternative means of either vacuum applied to the outlet or compressed air to the inlet. The new machine shown in Fig. 25 is a self-contained unit designed to handle oil-engine lubricating oil. The filter is mounted on the right with a clean oil tank beside it. In rear will be seen the vacuum pump, belt-driven from a small motor, with its associated compressed air cylinder. In the foreground are the switches which control the electric immersion heaters fitted in a water jacket around the filter. Dirty oil is drawn in through a large-bore pipe, from beneath the stand, and passed up the spaces between the filter packs, being warmed by the jacket of the filter. Its path is continued through the packs to the central passage, whence it passes out of the top of the filter chamber into the tank shown. It is drawn off as required through a tap. Flow is maintained by the vacuum pump which is connected to the header of the filter. For cleaning purposes the handle in the foreground is turned to a central position. The filter is then drained through an aperture in rear of the handle. At the same time, the vacuum pump connections are altered so that it charges the air bottle shown with compressed air. When sufficient pressure is attained the handle is turned to the extreme opposite position to that shown, and the compressed air is released into the filter header to blow oil back through the packs and out of the drain taking with it all dirt. This arrangement is suitable, we understand, for fitting to large oil engines to clean the oil from the sump during shut-down periods. An alternative filter for such engines is shown in Fig. 26. Here no auxiliary fittings are provided, as it is intended for mounting on the engine itself, the filter by-passing a small quantity of lubricant flowing in the engine system during running. The filter flow is assured by the engine oil pump, while cleaning is effected by a compressed air lead taken to the filter head.

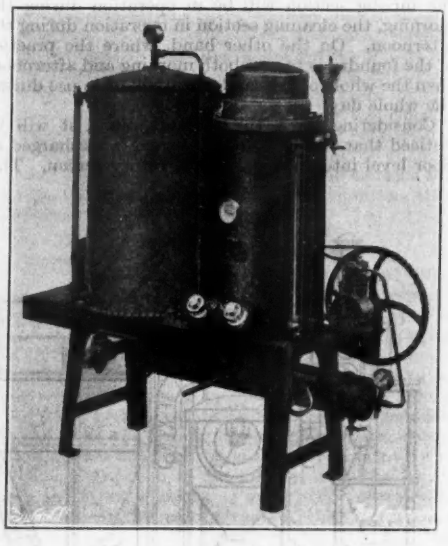


FIG. 25—SELF-CONTAINED FILTER UNIT FOR ENGINE OIL—STREAMLINE

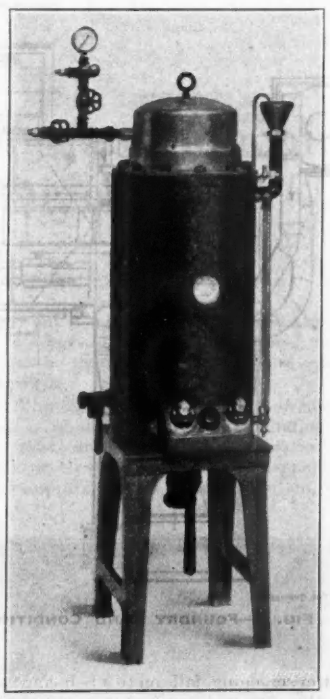


FIG. 26—FILTER FOR OIL ENGINE LUBRICATING OIL—STREAMLINE

COLEMAN FOUNDRY EQUIPMENT COMPANY, LTD.

An invitation issued by the Coleman Foundry Equipment Company, Ltd., 156, Strand, W.C.2, to all foundrymen to bring their own core boxes to the Exhibition and see them filled by the Coleman core-blowing machine, has resulted in an interesting demonstration. The invitation has been accepted as a challenge, the boxes produced being generally the most difficult that their owners could find. Nevertheless, the machine seems to be coming through the test successfully, in spite of the handicaps resulting from conditions at Olympia in the way of space restrictions, an admiring audience, and the temporary character of the installation. We illustrate the machine used in Fig. 27. It is entirely operated by compressed air at from 60 lb. to 85 lb. per square

inch pressure. The core box is placed on the table to the left and held there by means of the clamped plate shown on the extreme left, which receives the force of the impact. When clamping the box to the table, the inlet is lined up to the nozzle flange of the machine, elevation of the core box by the necessary amount being accomplished by the lever in the front of the machine. The box is held down by the clamping cylinder shown above it, which is adjusted by hand on to the box. Three levers grouped to the operator's hand on the extreme left of the illustration perform the final clamping operations and cause the sand to be shot into the core box. The first lever used operates the clamping cylinder, which presses down on the box to hold it shut against the sand pressure. The second lever causes the table to be driven forward, keeping the inlet of the core box home against the nozzle flange. The third lever causes the sand to be driven into the box. The method by which this is done obviates the necessity for putting the sand reservoir under pressure, and is claimed to prevent any entry of compressed air into the core boxes. The sand reservoir is in the middle of the machine and is fitted with an open filling hopper shown to the right. Immediately beneath is a "magazine" mounted on a horizontal axis, the end faces having openings similarly arranged to those of a service revolver magazine. When this third lever is brought to a vertical position the main piston is driven forward, causing the cartridge barrel to pass through the sand in the magazine and to bear against the nozzle flange. When the lever is jerked to the right and back, compressed air enters behind the wad of sand picked up by the cartridge barrel, and drives it into the core box. When the lever is turned over to the left, the main piston takes the cartridge barrel back to the starting position, and the magazine is jerked round to the next charge position. The empty space in it is filled by the fall of sand from the reservoir, assisted by the motion of the magazine. Should the core require more than one cartridge of sand, about 10 lb., a second "shot" is made. The time saved by the machine over hand operation varies, of course, but in certain cases the times are given as 30 seconds against 10 to 12 minutes. The advantage claimed for the machine, apart from speed, is that even pressure all over the core is obtained. In addition, the sand reservoir is at atmospheric pressure, so that no deterioration of the sand takes place, no compressed air enters the core box, a source of alteration of core-box shape, and simplicity of control by the use of pneumatic means obviates the necessity for long practice in handling and setting up the machine. Various sizes of core-blowing machines are on view, as well as several other interesting foundry equipment items.

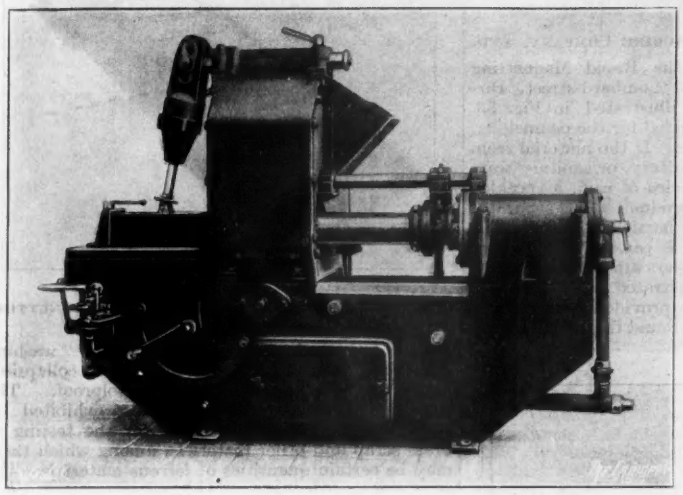


FIG. 27—CORE-BLOWING MACHINE—COLEMAN

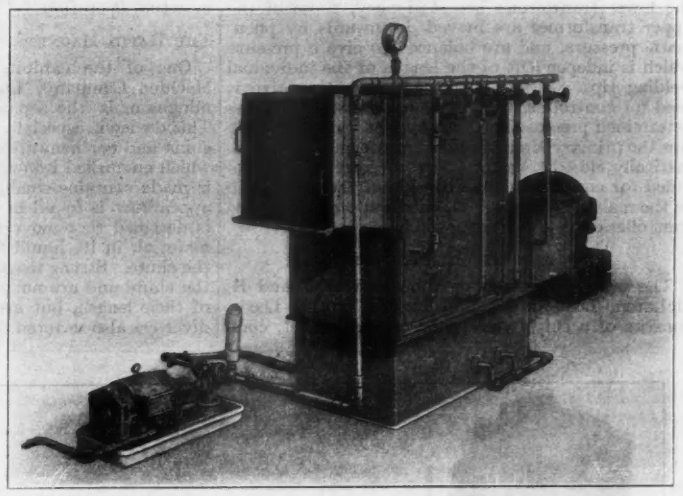


FIG. 28—FACTORY HEATING AND VENTILATING PLANT—OZONAIR

OZONAIR, LTD.

On the stand taken by Ozonair, Ltd., of Ozonair House, St. Leonard-street, London, S.W.1, there is a very complete display of the firm's products, including a 60 cubic foot per minute ventilation plant, a combined heating and ventilating unit capable of dealing with about 3000 square feet of floor space, a range of the Ozonair purifying apparatus covering the portable types as well as the large models for use in theatres, &c., a sectioned model of the "Ventex" air filter of the self-cleaning type, and a "Pure Air" plant for the production of sterile air in breweries, food factories, &c. The principle of operation of these plants has been frequently described in THE ENGINEER. It consists briefly of the provision of a "closed circuit" air-circulating system, which passes the air through heaters of either steam or hot water type, thence to an electric ozone producer to revive the air, and discharges it into the room in revived condition, to be drawn back again into the apparatus by the fan. Commendable features are the variable fresh air inlet, which allows the fan to draw directly from the outside atmosphere a variable proportion of its inlet air, the facility with which each unit can be dismantled, a feature which in no way spoils the compactness of the complete apparatus, and the excellent deodorising effect produced by the ozone method of air revival. The ozonisers are also used in the firm's deodorising plant, the air being passed several times through them in its circuit and emerging in a thoroughly fresh condition. In Fig. 28 we illustrate a typical factory heating and ventilation apparatus, illustrative of the neatness and simplicity of the plant.

SUPER CENTRIFUGAL ENGINEERS, LTD.

In Fig. 29 we illustrate the Sharples totally enclosed, high-capacity Super Centrifuge exhibited by Super Centrifugal Engineers, Ltd., Sharples House, Grosvenor-road, S.W.1. The method of operation and the principles involved are well known and have been described on several occasions in THE ENGINEER. They have not been changed in the present models except in detail. In the case of the type illustrated the rotor has been built to give the machine a capacity of about 700 gallons per hour of fuel or lubricating oil. This has been done with a bowl weighing 37 lb. empty and having a capacity for 10 lb. to 12 lb. of sludge. In addition, a very neat installation job has been made by including a direct-driven centrifugal pump mounted on the motor shaft of the machine, which provides the machine with its own circulation system irrespective of its position relative to the main flow, an important point for marine work. It will be recalled that the Sharples machines have a particularly high running speed, and the Super Centrifuge is claimed to develop the highest commercial centrifugal force of any machine available on the market, the force being 13,200 times that of gravity. It is obtained by rotating the bowl at 15,500 r.p.m. The bearing used for supporting the bowl is interesting, as it enables the bowl to take up its own centre of rotation. It consists of a double row of ball bearings of the self-aligning type. In addition to this machine, Super Centrifugal Engineers, Ltd., are exhibiting the Sharples totally enclosed motor-driven oil purifier recommended for lubricating oil purification purposes, their portable machine, and a self-contained unit mounted on a trolley and especially suitable for the purification of transformer and switchgear oils.

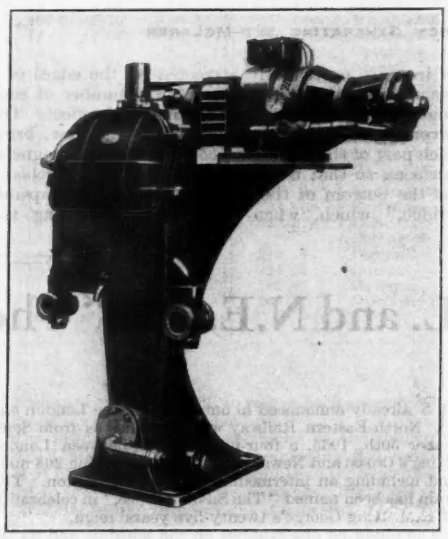


FIG. 29—HIGH CAPACITY CENTRIFUGE—SUPER CENTRIFUGAL

A smaller machine of the same range adapted for belt drive is also shown. This machine, with either form of drive, is especially popular where only small quantities of oil have to be dealt with. The laboratory high-speed machine is also on view. This model was described in our Exhibition Supplement in 1933. It has an overhead motor drive, which can be replaced by compressed air or steam turbine operation. The motor drive gives 25,000 r.p.m. to the bowl, but this can be increased to 50,000 r.p.m. with either type of turbine drive. Finally, the display includes the Sharples self-discharging horizontal bulk centrifuge, extensively used for the dehydration of crystalline products and for the extraction of large quantities of solid suspensions from liquids. The particular model exhibited has a 20in. diameter basket; other models have 36in., 48in., and 65in. baskets. Interesting features of this machine are the horizontal mounting of the centrifuge basket, and the method of removing solid matter at full speed by a mechanically operated knife, a great saving in labour costs. The baskets used may be of either the perforated or solid type, the former being for drying crystal products, the latter for sedimentation and decantation purposes. This machine was described by us in the Exhibition Supplement of the Shipping, Engineering and Machinery Exhibition, 1931.

NEW PROCESS WELDERS, LTD.

A twin spot welding machine with two transformers is exhibited by New Process Welders, Ltd., of Scotts-road, Southall, Middlesex. A limit has hitherto been imposed on welding in the centre of large sheets by the depth of the throat of the machine and the loss of power resulting from the sheet which constitutes a large magnetic mass in the secondary circuit. By applying both electrodes to the same surface of the sheet, as shown at A in Fig. 30, this difficulty was partly overcome. This method is applicable when the lower material is of heavier gauge than the upper material, or can be backed by a copper plate, but it is normally impossible to weld three thicknesses of material by this method. With the aid of the double transformer twin spot welder indicated at B in Fig. 30, however, it is possible to weld two or more thicknesses of material without limitations in regard to the size of the sheets. The material to be welded is inserted between two pairs of electrodes supplied with welding current from two independent transformers disposed on either side of the welding area. The flow of current through twin spot welds with a single transformer is indicated at A in Fig. 30, and that in the case of the twin transformer method at B in Fig. 30. The former method is only applicable to small gauge material or to one side welding of a thin gauge sheet to a heavy gauge section, but, as in the latter case the main part of the welding current flows straight across the work to be welded to the opposite electrode, it is possible to weld several

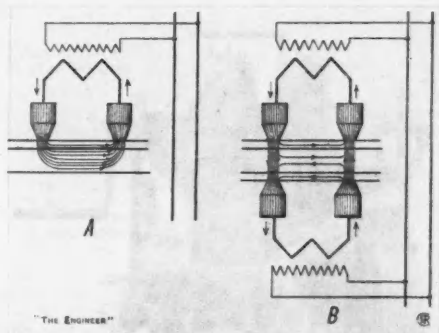


FIG. 30—ARRANGEMENTS OF WELDING ELECTRODES—NEW PROCESS

layers of different thicknesses or material that is partly insulated. No heat marks are left on the surface between the two spot welds.

The double transformer twin spot welder has two 25-kVA transformers, each with primary tappings, giving twenty-five variations in the secondary voltage, and as the casing of each transformer forms the secondary, flux loses are reduced to a minimum. All manually operated controls and switchgear are operated at the low potential of 25 volts. Oil-immersed contactors, with contacts claimed to have a long life, are provided. While the welding tips of the lower transformer are stationary, those of the upper transformer are moved downwards by pneumatic pressure, and are balanced to give a pressure which is independent of the length of the individual welding tips. A foot-operated pneumatic valve is used for controlling the machine, and when the predetermined pressure has been applied by the welding tips the primary circuits of the transformers are automatically closed. Various types of gear can be provided for controlling the duration of the weld, such as the maker's "N.P.C." patented automatic current controller or a special time switch.

J. and H. McLaren, Ltd.

The principal exhibit on the stand of J. and H. McLaren, Ltd., of Midland Engine Works, Leeds, consists of a ship's emergency generating set, comprising a McLaren M.D.B.M. type five-cylinder engine with a designed output of 87 b.h.p. at 1000 r.p.m., which is coupled directly to a Laurence Scott and Electromotors, Ltd., 50-kW, 220-volt, enclosed ventilated type D.C. generator. As Fig. 31 shows, the set is mounted on a fabricated steel bed-plate, and it is complete with air starting gear. The normal output above mentioned refers to a sea level performance at a temperature of 62 deg. Fah., but the provision of a large radiator and fan makes the set

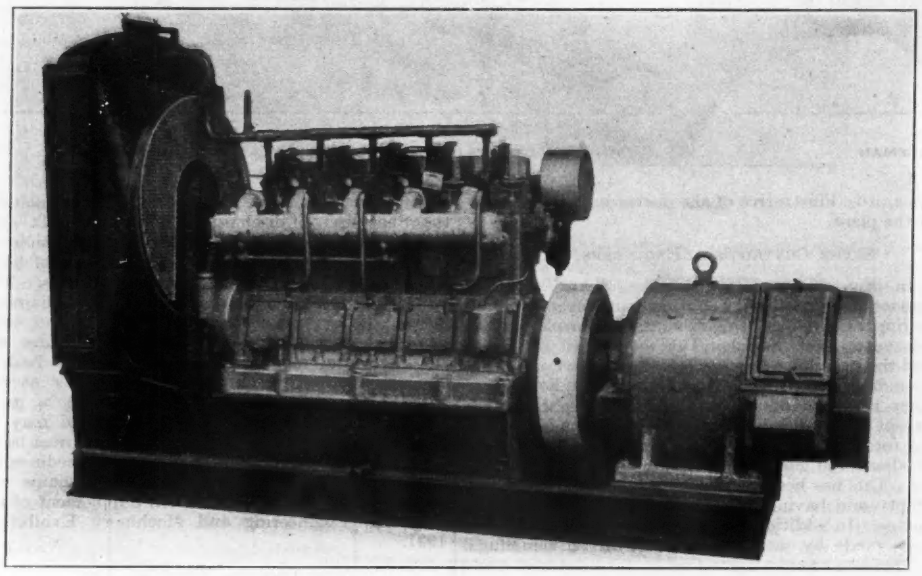


FIG. 31—87 B.H.P. MARINE EMERGENCY GENERATING SET—McLAREN

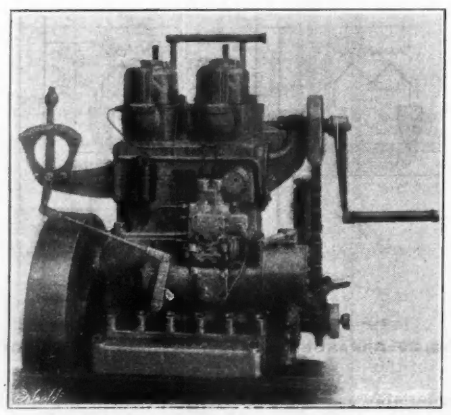


FIG. 32—30 B.H.P. TWIN-CYLINDER ENGINE—McLAREN

suitable for tropical services. The engine follows the standard McLaren practice and operates on the pre-chamber combustion system with C.A.V.-Bosch fuel pumps and atomisers. The cylinder bore is 135 mm., with a stroke of 200 mm., and the fuel consumption is 0·47 lb. per b.h.p. hour at full load, the corresponding lubricating oil consumption being 0·01 lb. per b.h.p. hour. The lubrication system is of the latest forced feed type and splash lubrication is relied upon for the lubrication of the cylinder walls. Another engine shown on the stand, which we illustrate in Fig. 32, is a twin-cylinder unit of the same type and dimensions with a designed output of 30 b.h.p. at 800 r.p.m. The firm is also exhibiting a McLaren-S.L.M. four-cylinder marine engine with Parsons reverse gear and hand and electric starting equipment. This unit has an output of 25 b.h.p. at 1250 r.p.m. and a bore of 95 mm. and a stroke of 125 mm. The gear is designed to give equal speeds ahead and astern. A twin-cylinder L.M. unit of similar design has a designed output of 20 b.h.p. at 1250 r.p.m., with a bore of 105 mm. and a stroke of 150 mm. All the engines above referred to are equipped with C.A.V.-Bosch fuel pumps and atomisers, and several of the units are demonstrated in actual operation.

The Rapid Magnetting Machine Company, Ltd.

One of the exhibits of the Rapid Magnetting Machine Company, Ltd., of Lombard-street, Birmingham, is the separator illustrated in Fig. 33. This device is especially intended for the enamelling, china and earthenware trades. If the material from which enamelled ironware, pottery, or sanitary ware is made contains small particles of iron, a speckled appearance is found in the product. This separator is designed to remove these particles of iron. The material, in its liquid form, is caused to run down the chute. Strong magnetic bars are stretched across the chute and are not only serrated in the direction of their length, but are also provided with vertical diverters also serrated. It is found that fine particles of iron are particularly attracted by the edges of a magnet and the serrations create a number of such edges and thereby increase the magnetic effect. The diverters, of course, by obstructing the flow, bring each part of the liquid into contact with the magnetic surfaces, so that it shall be thoroughly "searched." At the bottom of the chute there is a "collapsible bridge," which, when the current actuating the magnets is turned on, is magnetically raised to the position shown in the engraving. On the current being switched off the "bridge" "collapses" and swings into a position which diverts the flow of the fluid away from the path of the cleaned liquid into a suitable receptacle. At intervals, of course, the

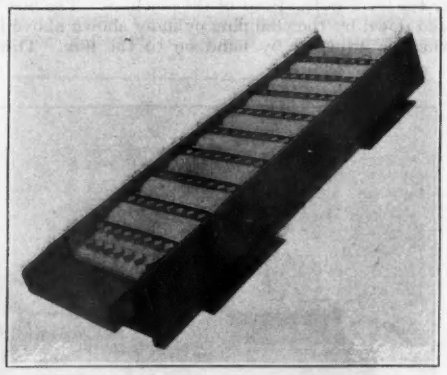


FIG. 33—MAGNETIC SEPARATOR—RAPID MAGNETTING

current is turned off in this manner for "washing down" and the automatic action of the collapsible bridge makes the device practically foolproof. The magnet illustrated in Fig. 34 is also exhibited by the firm. It is used especially for the testing of brass scrap and other materials, among which there may be certain quantities of ferrous materials. The

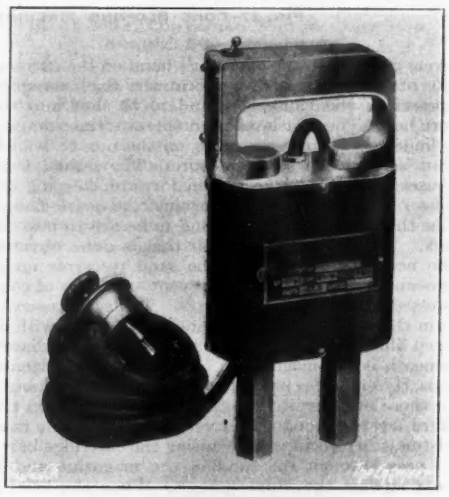


FIG. 34—TESTING MAGNET—RAPID MAGNETTING

presence of these materials, of course, alters the value of the scrap to an extent dependent on its amount. The magnet is supplied with a length of flex and has a switch mounted on the hand grip.

(To be continued.)

L. and N.E.R.—"The Silver Jubilee" Train

As already announced in our columns, the London and North-Eastern Railway will introduce as from September 30th, 1935, a four-hour service between London (King's Cross) and Newcastle, the distance being 268 miles and including an intermediate stop at Darlington. This train has been named "The Silver Jubilee," in celebration of H.M. King George's twenty-five years' reign.

The following observations on the schedule and on the design of the engine and train have been supplied by the L. and N.E. Railway Company.

The Time Table.

The high average speed can only be maintained by running at high speeds uphill, and it is not anticipated that it will be necessary to run at extra high speeds on the falling gradients. If the speed of uphill running on a 20 miles section can be increased from 40 to 60 m.p.h. a saving of 10 minutes is realised, but if the speed of downhill running over 20 miles is increased from 60 to 80 m.p.h. 5 minutes only is saved. For the 268 miles from Newcastle to London the average speed including a 2 minutes' stop at Darlington is 67·07 m.p.h.

For the 36 miles from Newcastle to Darlington 40 minutes is allowed and the average speed is only 54 m.p.h. This lower average speed is owing to restrictions of 25 m.p.h. through Durham and two other permanent speed restrictions of 20 m.p.h. owing to colliery workings.

For the 232 miles from Darlington to London 198 minutes only is allowed, or an average speed of 70·3 m.p.h., notwithstanding the severe speed reductions through York, Selby, and Peterborough to 15, 30, and 10 m.p.h. respectively.

Details of the mileage, running times and speeds are given in the table on the next page.

From a close analysis of the timings it will be seen that high speed uphill is the feature of the schedule. For instance, over the 29 miles' section from Peterborough to Grantham, with its long rising gradient of 9 miles, varying from 1 in 200 to 1 in 178, 24½ minutes is allowed in running, but in the opposite direction the time allowed is only reduced to 24 minutes, the speeds being 71·3 and 72·7 m.p.h. respectively.

Streamlining.

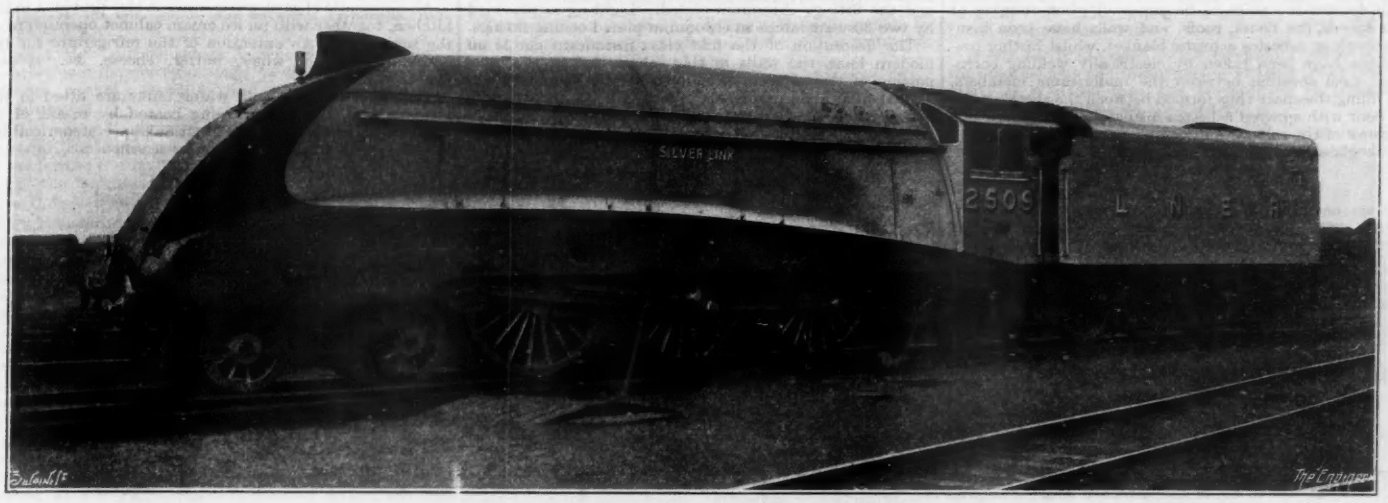
Recognising that the power required to overcome the air resistance on the front of the engine at 70 m.p.h. is approximately 50 per cent. greater than that required at 60 m.p.h., it becomes necessary to facilitate the running, and in the interests of coal economy that the front of the engine should be streamlined.

The form of streamlining to give the best results on aircraft is not necessarily the most suitable for a train or motor car. The nose of the airship or the fuselage of the aeroplane is always pointed directly into the wind whatever its direction. Trains and racing motor cars have to follow a track, and consequently the air flow owing to side winds is almost always more or less on one quarter.

An extended investigation has been made into locomotive streamlining from three aspects: (1) reducing the head resistance; (2) lifting the steam and smoke; and (3) minimising the disturbance of the atmosphere alongside the train. A wind other than a head-on wind causes an increase in pressure on the windward side of the boiler barrel, but also induces a reduced air pressure on the lee side, and this partial vacuum draws the steam and smoke down into it and tends to obscure the lookout. If the locomotive front end is designed with a vertical wedge front to pierce the atmosphere by parting it to the sides,

L. AND N. E. RAILWAY—"SILVER LINK" STREAMLINED LOCOMOTIVE

MR. H. N. GRESLEY, CHIEF MECHANICAL ENGINEER



the side wind effect is aggravated and the tendency of the steam and smoke to drift along the boiler barrel is increased. Then, too, considerable disturbance is caused laterally and this is felt by passing trains.

For these reasons Mr. Gresley decided that the best form of front end was a horizontal wedge, as this would cause an upwardly rising current of air to sweep past the chimney and along the boiler barrel top and by its velocity would assist in carrying the steam and smoke clear over the cab, besides avoiding any lateral displacement of the atmosphere. The running boards were given the form of an aerofoil for the same reason. The form of streamlining adopted is very similar to that incorporated by Monsieur Bugatti in his high-speed railcars in France and in his racing motor cars.

THE LOCOMOTIVES.

Four engines are being built for this service, the first of which has been named "Silver Link."

The streamlining of the front end covers over the smoke-box front end and door. In order to give access to the smoke-box the sloped front plate is divided into two parts, the larger hinged at the top lifting upwards and the lower hinged at the bottom lifting forward and downwards over the buffers. These doors are operated from the ground by a handle on a cross shaft in front of the smoke-box, the lower door overlapping the top door when closed. Inspection doors have been provided along the sides of the engine to give access to the different parts of the motion.

The engine is a three-cylinder simple expansion "Pacific" type locomotive with an eight-wheeled tender. The boiler pressure has been increased to 250 lb. per square inch. The grate area is 41½ square feet, a new design of fire-bar being used, giving air space openings equal to 56 per cent. of the grate area. Part of the grate is arranged to drop. The ashpan is completely welded and the design gives a free air flow under the outer side bars. The boiler barrel is made in two courses. The first course is parallel, 5ft. 9⅜in. outside diameter, the plates being ⅞in. thick; the second course is conical, having a maximum diameter of 6ft. 5in. and is of plate ⅞in. thick. The distance between tube plates is 17ft. 11⅛in.

The steam collector is a steel pressing integral with the dome, the steam supply being taken through a series of ⅛in. slots cut in the top of the barrel plate. The fire-box is of copper and, including the combustion chamber, is 10ft. 1⅜in. long. The throat plates of both the copper box and of the outer casing are each in one piece. The copper wrapper plates are ⅜in. thick and the tube plate 1½in. thick.

The regulator is of the double-beat type and feeds into a main steam pipe of 7in. diameter.

The superheater is of the Robinson type, the forty-three elements being expanded into a cast steel header. The elements are of the short loop type and extend to within 9in. of the copper tube plate.

The whole of the boiler barrel and fire-box is insulated with mattresses comprising five layers of "Alfol" foil and 1½in. mesh wire netting. The outer covering is steel sheeting, 16 S.W.G. thick.

The boiler is fed by two injectors, that on the right-hand side of the engine being a Davies and Metcalfe No. 10 exhaust steam injector, and that on the left-hand side a live steam under-footplate injector.

The three cylinders are each 18½in. in diameter by 26in. stroke. Each cylinder is cast as a separate unit, the exhaust from the outside cylinders being carried to the blast pipe base through a cast steel saddle. The piston valves are of the narrow ring type with ring control. The valves are 9in. diameter with a steam lap of 1⅛in. Each cylinder has its own 5in. diameter steam pipe from the header, and special care has been exercised to make the exhaust passages smooth in order to reduce the friction.

The blast pipe nozzle is 5⅛in. diameter and is provided with a jumper ring of the type introduced by the late Mr. Churchward on the G.W.R., to relieve back pressure when working the engine at a long cut-off.

The piston and rod are combined in one forging of B.S.S. Class "C" steel. The connecting and coupling rods of nickel-chrome steel are similar to those at present fitted to the ordinary "Pacific" engines. Forty per cent. of the total reciprocating weight is balanced at the wheel rim.

The valve gear is of the company's standard type, in which the outside valves are operated by means of Walschaerts gear, and the inside valve by the Gresley gear incorporating a system of equal and 2 : 1 levers. The valve gear throughout is fitted with ball and roller bearings. The maximum cut-off is 65 per cent., at which position the valve travel is 5¾in.

The coupled axle-boxes are lubricated by means of a Wakefield six-feed mechanical lubricator and Armstrong oiler pads are used in the axle-box trays. A Wakefield mechanical lubricator is also used for the lubrication of the valves and cylinders, one feed being placed in each steam pipe and one on the top of each cylinder barrel. The two lubricators are driven from one return crank on the right-hand trailing crank pin and the gear is fitted with ball bearings throughout. Four oil boxes, each with nine syphon feeds, lubricate the valve spindles, piston-rods, &c.

The locomotive is fitted with the vacuum brake. The three 21in. diameter brake cylinders are arranged to transmit their load to one main shaft and give a total brake power equal to 86 per cent. of the adhesive weight. The brake shafts are of forged steel, the brake arms and levers being electrically welded.

The front of the cab is vee-shaped and provides an exceptionally wide angle of vision for the engine crew. Reversing gear of the vertical screw type fitted with ball thrust washers and with a special vacuum locking apparatus is provided. Bowden wire is used for the sand gear and cylinder cock controls, as well as for operating the whistle, the latter being of a special type fitted immediately in front of the chimney.

Bucket seats are provided for the driver and fireman, and to eliminate back draught flexible rubber roofing is fitted over the gap between the cab and tender. In addition to the usual cab fittings, a Cambridge pyrometer and Flaman speed recorder are also fitted.

The tender is of the corridor eight-wheeled type and is equipped with well and water scoop, its capacity being 5000 gallons of water and 8 tons of coal. It is fitted with standard Pullman vestibule and buckeye couplers and the back is rounded to conform to the shape of the carriages to which it is coupled.

The principal dimensions and ratios are given in a table and weight diagram on the next page.

THE TRAIN.

The train, which will be known as "The Silver Jubilee," is 392ft. long and consists of seven vehicles, the formation being as under :—

Third-class brake	Articulated	30 seats
Third-class corridor	Articulated	42 seats
Third-class restaurant car	Articulated	48 seats
Kitchen car	Articulated	28 seats
First-class restaurant car	Articulated	48 seats
First-class semi-open	Articulated	30 seats
First-class brake	Articulated	20 seats

The train is vestibuled throughout and has a total seating capacity of 198, the tare weight being 205 tons. The bodies of the twin articulated vehicles and the two restaurant cars of the triplet set are each 56ft. 2½in. long and 9ft. wide, whilst the kitchen car of the triplet set is 45ft. 11in. long and 9ft. wide.

The exterior finish of the train is a distinct departure from the company's usual practice. Instead of the standard varnished teak, the bodies are panelled in No. 16 gauge steel and covered with aluminium rexine, the cornices, door and window facias and bottom beading being in stainless steel. Exterior projections have been reduced to a minimum, and in order further to reduce the air resistance a skirting has been fitted between the bogies extending from the bottom of the body to within 10½in. of the rail. The spaces between the articulated ends of the vehicles have been closed by means of a special rubber sheeting with aluminium finish supplied by G. Spencer Moulton and Co., Ltd., which is fitted with initial tension.

The bogies are of the L.N.E.R. standard four-wheeled compound bolster type. The underframes are of steel rigidly trussed, the whole being fabricated by means of electric welding.

The body framing is of teak throughout, the floors being bolted directly on the underframes, no body cushions being

Point to Point Mileages, Running Times and Speeds, Newcastle, Darlington, King's Cross.

Distance from Newcastle.	Station.		Point to point. Time.	Distance.	Speed.
Miles chains.		a.m.	Min.	Miles ch'ns.	M.p.h.
	Newcastle (Central) .. .. Dep.	10.0			
5 39	Birtley .. .. Pass	10.8	8	5 39	41·2
14 3	Durham .. .. Pass	10.18	10	8 44	51·3
23 18	Ferryhill .. .. Pass	10.28	10	9 15	55·1
36 6	Darlington .. .. Arr.	10.40	12	12 68	64·2
	Darlington .. .. Dep.	10.42			
41 21	Eyrholme .. .. Pass	10.48	6	5 15	51·9
50 20	Northallerton .. .. Pass	10.55	7	8 79	77·0
58 0	Thirsk .. .. Pass	11.1	6	7 60	77·5
69 2	Alne .. .. Pass	11.9	8	11 2	82·7
80 16	York .. .. Pass	11.19	10	11 14	67·1
94 2	Selby .. .. Pass	11.33	14	13 66	59·3
108 11	Shaftholme Junction .. .. .. Pass	11.45	12	14 9	70·6
112 30	Doncaster (Central) .. .. .. Pass	11.49	4	4 19	63·5
		p.m.			
129 57¾	Retford .. .. Pass	12.3	14	17 27¾	74·3
148 18¾	Newark .. .. Pass	12.19	16	18 41	69·4
162 70½	Grantham .. .. Pass	12.32	13	14 51½	67·6
191 78	Peterborough (North) .. .. .. Pass	12.56	24	29 7½	72·7
209 37½	Huntingdon (North) .. .. .. Pass	1.12	16	17 39½	65·6
236 33½	Hitchin .. .. Pass	1.33	21	26 76	77·0
250 52½	Hatfield .. .. Pass	1.44	11	14 19½	77·7
268 27	King's Cross .. .. Arr.	2.0	16	17 54½	66·3

Overall speed 67·07 m.p.h.

Point to Point Mileages, Running Times and Speeds, King's Cross, Darlington, Newcastle.

Distance from King's Cross.	Station.		Point to point. Time.	Distance.	Speed.
Miles chains.		p.m.	Min.	Miles ch'ns.	M.p.h.
	King's Cross .. .. Dep.	5.30			
17 54½	Hatfield .. .. Pass	5.48	18	17 54½	58·9
31 73½	Hitchin .. .. Pass	5.59	11	14 19½	77·7
58 69¾	Huntingdon (North) .. .. .. Pass	6.19	20	26 76	80·8
76 29	Peterborough (North) .. .. .. Pass	6.35	16	17 39½	65·6
105 36½	Grantham .. .. Pass	6.59½	24½	29 7½	71·3
120 8½	Newark .. .. Pass	7.11½	12	14 51¾	73·2
138 49½	Retford .. .. Pass	7.27	15½	18 41	71·7
155 77	Doncaster (Central) .. .. .. Pass	7.41	14	17 27¾	74·3
160 16	Shaftholme Junction .. .. .. Pass	7.45	4	4 19	53·5
174 25	Selby .. .. Pass	7.56½	11½	14 9	73·6
188 11	York .. .. Pass	8.9	12½	13 66	66·4
199 25	Alne .. .. Pass	8.20	11	11 14	60·9
210 27	Thirsk .. .. Pass	8.29	9	11 2	73·5
218 7	Northallerton .. .. Pass	8.35	6	7 60	77·5
227 6	Eyrholme .. .. Pass	8.42	7	8 79	77·0
232 21	Darlington .. .. Arr.	8.48	6	5 15	51·9
	Darlington .. .. Dep.	8.50			
245 9	Ferryhill .. .. Pass	9.3	13	12 68	59·3
254 24	Durham .. .. Pass	9.15	12	9 15	45·9
262 68	Birtley .. .. Pass	9.23	8	8 44	64·1
268 27	Newcastle (Central) .. .. .. Arr.	9.30	7	5 39	47·0

Overall speed 67·07 m.p.h.

used. The steel panels are bedded to the pillars with a special paste before being finally screwed into position, and special weather-resisting aluminium finish rexine is secured to the steel panels by means of a chemical adhesive. All edges of the fabric are covered by the stainless steel strips previously referred to.

To deaden the noise to be expected when running at high speeds, the floors, roofs, and walls have been insulated with an asbestos acoustic blanket, whilst further precautions have been taken by electrically welding corrugated steel sheeting between the underframe members, and filling the space thus formed between the sheeting and the floor with sprayed asbestos insulation. The large side windows of the saloons and compartments are fitted with double glass having an air space of ¼in. between, in order to reduce to a minimum the transmission of heat and sound.

Plywood has been used throughout for the interior lining of each body with the exception of the ceilings, which are of special millboard. All cross partitions with the exception of those in the restaurant cars are of block plywood.

The whole of the train with the exception of the kitchen car is fitted with J. Stone and Co.'s automatic air conditioning and heating system. Fresh filtered air is forced into the compartments through outlets near the floor level, and in cold weather the air is heated to the required temperature according to the predetermined setting of a special compensated thermostat. The equipment consists of a unit, suspended from the underframe, which contains the necessary fan, air filters, and heating apparatus, from which the conditioned air is conveyed to the compartments by suitably lagged metal ducts, and passes to the outside atmosphere by means of extractor type sliding shutter ventilators situated over each body side light and also through perforated metal grids situated over each compartment sliding door.

First-class Compartments.

The interior decoration of the various units introduces several novel features. The first-class compartments, each of which seats four passengers, have been decorated in blue with chromium-plated metal fittings. The walls above the seat backs are covered with blue rexine and the ceiling with rexine of a lighter shade. The basis of the whole design is to provide a feeling of spaciousness in the compartment, and this is enhanced by the provision of vertical chromium-plated luggage strips on the partition.

The seats are upholstered in silver and blue broche rep, the seat fillings being of the Vi-Spring type. The hinged centre armrests, the side armrests and the headrests have fillings of Dunlopillo rubber. Loose feather cushions in blue silk are also provided. Each window is provided with a blind of blue rexine, whilst silver and blue silk curtains are fitted to each body side light.

Tubular lamps are used throughout, a 35-watt lamp in a chromium-plated reflector being fitted in the centre of the ceiling. Tubular reading lamps of 15 watts capacity are fitted in each corner above the seat back. Each tubular reading lamp previously described provides illumination from one particular position, but in order to give a good general lighting, just above seat level a large rectangular mirror has been placed over each seat back below the parcels rack. This mirror is so inclined that the light from the tubular lamp in the ceiling is reflected on to the book or newspaper which the passenger may be reading. The floor is covered with blue linoleum, over which is laid a blue jaspe Wilton rug.

Dining Cars and Third-class Compartments.

The third-class compartments are designed to seat six persons in each, the decorations being carried out in green and the fittings chromium-plated. Lighting is provided by two 30-watt lamps in chromium-plated ceiling fittings.

The decoration of the first class restaurant car is on modern lines, the walls in this saloon and in the open portion of the adjacent semi-open car being panelled in figured Australian maple.

The whole finish is entirely flush, the necessary decorative and architectural effects being provided by the grain of the timber, the whole forming a hygienic finish free from any mouldings or projections which might collect dust.

Loose chairs are provided, one on each side of a centre gangway, and are upholstered in a blue tapestry with trellis design, the seat fillings being of the Vi-Spring and Vito type.

The ceiling is tinted pale blue. The floor is covered with a sponge rubber underlay, on which is placed a blue jaspe Wilton carpet.

Tubular lighting is again employed in this saloon, two 35-watt tubular opal lamps in chromium reflector type fittings being fixed to the cornice above each side window. A fixed standard table lamp with a beige Nacrolaque shade is fixed to the waist rail at each table.

The walls of the third-class restaurant car are flush panelled in quartered teak, the fittings throughout being chromium-plated. The fixed seats are arranged two on one side of the gangway and one on the other, and are upholstered in green uncut moquette.

The carpet in the third-class restaurant car is fawn with a black and green pattern; a sponge rubber underlay is provided. Each section is lighted by means of one 60-watt opal lamp in the centre of the ceiling.

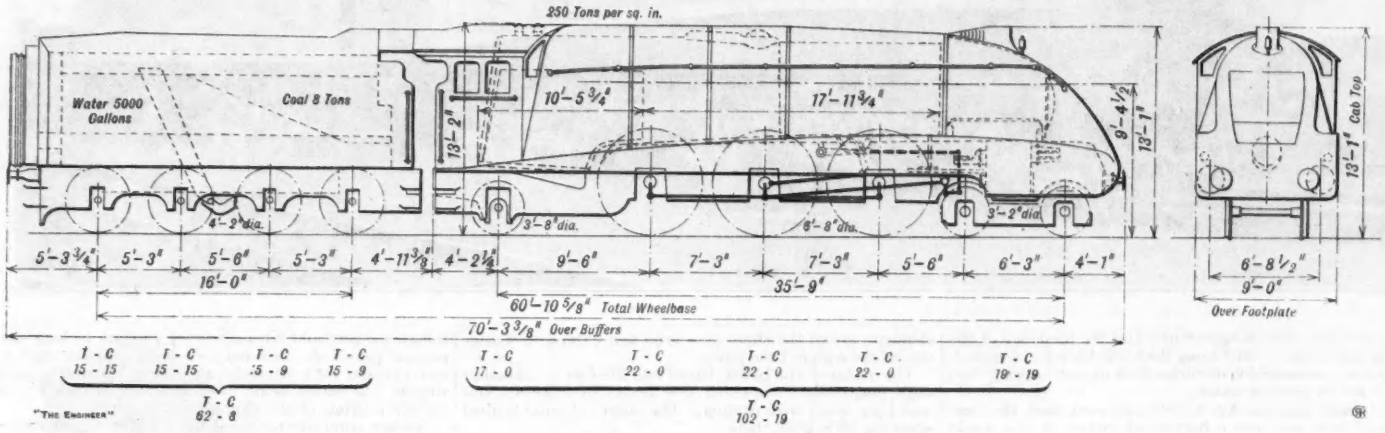
The Kitchen.

The kitchen, which comprises the centre unit of the triplet restaurant car set, has a large kitchen, pantry, attendants' compartment and attendants' toilet, and is provided with electric cooking apparatus. The power equipment follows generally the lines of the previous equipments supplied by J. Stone and Co., but considerable changes have been made in the actual cooking appliances, the finish of which is generally in stainless steel and vitreous enamel.

With the exception of the coffee machine, the actual cooking equipment has been supplied by Henry Wilson, Ltd., as sub-contractors. Previous stoves and accessories have been built up with cast iron sections, but in the equipment now being described the framing is of light steel sections electrically welded. A great saving in weight is thereby obtained, together with greater economy in current due to a reduction in radiation losses. The main cooking range is fitted across one end of the kitchen, and comprises a roasting oven, steaming oven and grill, together with a boiling table having four boiling plates. A special feature of the boiling table is that the whole of the top surface is heated and is not, as hitherto, composed of small separate heating elements. A hot cupboard has been provided on the corridor side, the top of which has been constructed to form a heated carving table with special wells for sauces, gravies, &c. An auxiliary hot water tank of 4 gallons capacity is provided for kitchen use. A fish fryer is also provided. A novel feature is the provision of sinks, each having a 1-kW heating element clamped to the underside, to ensure that the water remains hot during the process of washing up. The tops of the benches are covered in stainless steel plates.

An automatic electric refrigerator is also provided in the kitchen, together with an ice cream cabinet operated from the same unit. An extension of the refrigerator for the accommodation of wines, butter, cheese, &c., is also fitted.

The main hot and cold water tanks are fitted in the corridor roof, the former being heated by means of an electric element together with an auxiliary steam coil for use during the autumn and winter seasons.



Leading Dimensions and Ratios.

Grate :	
Length of slope	5ft. 10 11/16 in.
Width	6ft. 11½in.
Grate area	41·25 sq. ft.
Fire-box :	
Height of crown above foundation ring :	
Front	6ft. 8 13/16 in.
Back	6ft. 0 5/16 in.
Interior length at top	8ft. 11⅜in.
Interior width at boiler centre	5ft. 4½in.
Thickness of copper plate :	
Sides and back	5/16 in.
Tube plate	1½in.
Boiler :	
Outside length of fire-box overall	10ft. 5½in.
Outside length of fire-box at bottom	6ft. 8in.
Outside width of fire-box at bottom	7ft. 9in.
Maximum diameter of barrel	6ft. 5in.
Length of barrel	17ft. 11⅜in.
Thickness of barrel plates	7/16 in. and 13/16 in.
Thickness of wrapper plates	5/16 in.
Tubes, small :	
Material	Steel
Number	121
Diameter outside	2¼in.
Thickness	10 I.W.G.
Tubes, superheater flue :	
Number	43
Diameter outside	5½in.
Thickness	5/16 in.
Length between tube plate	17–11⅜in.
Heating surface :	
Fire-box	2312 sq. ft.
Tubes	1281·4 sq. ft.
Flues	1063·7 sq. ft.
Total evaporative heating surface	2576·3 sq. ft.
Superheater :	
Number of elements	43
Diameter inside	1·244in.
Heating surface	748·9 sq. ft.
Total heating surface	3325·2 sq. ft.
Two Ross "pop" safety valves	3½in. dia.
Working pressure	250 lb. per sq. in.

Axles, journals :	Dia.	Length.
Bogie	6½in.	by 9in.
Coupled	9½in.	by 11in.
Trailing	6in.	by 11in.
Crank pins :		
Outside	5½in.	by 6in.
Inside	8½in.	by 6in.

Coupling pins :	
Leading	4in. by 4½in.
Driving	6in. by 4½in.
Trailing	4in. by 4½in.
Springs :	
Bogie : Helical, 10½in. long, free, 5 1/16 in. outside diameter, Timmis section	
Coupled : Laminated, 16 plates, 5in. wide by ½in. thick, 4ft. centres	
Trailing : Laminated, 11 plates, 5in. wide by ½in. thick, 4ft. 6in. centres	
Brakes	Vacuum
Cylinders : Number	Three, 18½in. dia. by 26in. stroke
Motion, type :	
Outside	Walschaert
Inside	Gresley
Valves	Piston
Diameter of valves	9in.
Maximum valve travel	5½in.
Steam lap, outside cylinder	1¼in.
Steam lap, inside cylinder	1 1/16 in.
Exhaust lap	Nil
Cut-off in full gear	65 per cent.
Tractive effort at 85 per cent. boiler pressure	35,455 lb.
Total adhesive weight	148,176 lb.
Adhesive weight/tractive effort	4·18

London and North-Eastern Railway "Silver Link" Locomotive

The switchboards are in general similar to those on previous equipments of this type, except that the main switchboard is of a special type in which the bodies of the indicator lamps and switches are enclosed, the switchboard being specially ventilated.

An automatic hot water boiler, by W. M. Still and Co., Ltd., supplies hot water to all sinks in the kitchen and pantry.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

HIGH-SPEED TRAINS AND VIBRATION.

Sir,—I am, of course, very pleased to find that my friend Mr. Dewhurst agrees with me that the usual amount of play between the flanges and rails is excessive and undesirable, although he proposes a much more difficult and costly remedy, for reasons that I am by no means sure are sound.

I should like to draw attention to a most interesting and quite unsuspected phenomenon which is brought to light in a valuable paper read at Lucknow by Mr. C. W. Clarke, and published in the current number of the *Journal* of the Institution of Locomotive Engineers (page 469). It is that on the G.I.P. Railway "with standard coaching stock, for each specific radius of curvature, there is a critical speed, at which speed the train resistance on the curve is less than that on level tangent track."

I think the only possible explanation is that the running is steadier, owing to the flanges settling against the outer rail (as the speed goes up still more, of course, the friction increases).

If this theory is correct, the argument for reducing the play is strengthened.

C. F. Dendy Marshall.

Guildford, September 18th.

It is reported that oil has been struck at Heide, in Holstein, Germany, the well having a daily output of 18 tons.

Rail and Road.

DURING trials with a dynamometer car the new L.N.E.R. train "Silver Jubilee" reached a speed of 101 m.p.h. on the main line between Doncaster and Peterborough.

THE L.M.S. turbine-driven locomotive, "No. 6202," described and illustrated on page 14 of THE ENGINEER of July 5th, is now working express trains between Euston and Liverpool.

SURBITON and Woking stations, on the main line of the Southern Railway, are to be enlarged and improved. At the former station there is to be a new loop line, whilst one of the features at Woking is to be the replacement of the three existing signal-boxes by one central box.

THE Minister for Industry and Commerce stated recently in the Irish Free State Legislature that the two two-coach trains, equipped with the Drumm battery, have been operating successfully and economically on the Dublin-Bray section since 1932 and have covered a mileage of approximately 156,000. Expert examination of the cells, which have been in service on the railway under the most arduous conditions, justifies the directors of the Great-Southern Railways, the Minister said, in guaranteeing ten years' life in traction service.

WHEN a Brighton Corporation tramcar was descending Ditchling-road, where the gradient varies from 1 in 11 to 1 in 69, on September 11th the car got out of control. Owing to the greasy state of the rails, due to fallen leaves, the wheels locked and the car skidded for a distance of 400 yards when it reached some junction points and was derailed and overturned. Whilst out of control the car struck a cyclist who was knocked down and killed. At the coroner's inquest on the following Friday, it was stated that that was the first fatal accident for thirty-four years. Each year the Brighton tramways carry about twenty-four million passengers, and, next to Halifax, Brighton is the hilliest town to possess a tramway system in the country. A verdict of "Accidental Death" exonerating the driver was returned. The accident was inquired into on behalf of the Ministry of Transport by Colonel Woodhouse on Tuesday, the 24th.

IN connection with the present programme of extensive alterations and modernisation of motive power depôts which is being carried out by the L.M.S. Railway, further improvements at a number of places, including the provision of larger engine turntables, have been sanctioned. In order to deal with the larger wheel-based engines now being constructed, nine turntables of increased diameter are to be installed as follows:—Two of 70ft. at Aintree and Camden (London); six of 60ft. at Bletchley, Derby, Goole, Mold Junction, Windermere, and Southport; and one of 55ft. at Derby. These new turntables will all be of the articulated type, and three new tables of this type will be provided to displace three balanced turntables at Perth (70ft.), Nottingham (60ft.), Canklow (55ft.), which require renewal. In addition to the installation of the new and larger turntables, seventy existing turntables at various motive power depôts are to be fitted with vacuum-operated turning gear to avoid engines having to be turned by hand.

ONE of the fatal accidents, in that unfortunate year, in that respect, of 1915, occurred on September 6th at Newark, on the then Great Northern Railway. It is appropriate to mention this case at this time, not so much because it happened twenty years ago, but because of the reference in the report thereon to the Buckeye coupler which has recently been very much in evidence because of the Welwyn disaster of June 15th last. During shunting operations on the adjoining sidings a wagon was derailed which fouled the down main line on which the 5.45 p.m. express from King's Cross to Leeds was approaching. The engine of the express remained on the rails, but the whole of the eleven coaches were derailed. One passenger was killed, but only fifteen were injured, although there were over 251 passengers and eleven servants on the train. The late Colonel Druitt was one of the passengers, and he held the subsequent inquiry. He reported that the vehicles were fitted with the Buckeye coupler, and that the only broken coupling was between the second and third coaches. "These couplings," he observed, "are very strong, and it is possible that the small damage done to the train, although derailed when running at a speed of from 60 to 70 m.p.h., was due to the strength of the coupling keeping the carriages connected together, one behind the other in a more or less direct line, and preventing any tendency for one or more to get broadside on to the others, and for the underframe of one car to ride over that of the next one to it, resulting in one telescoping into another."

A GOOD deal has been written of late as to the use of the 7ft. gauge by Brunel for the Great Western Railway, but we have not seen any recent mention of the facts that permitted that departure from what had till then been standard practice. Nicholas Wood, in the third edition (1836) of his "Practical Treatise on Railroads," said that when the Liverpool and Manchester Railway was under consideration a Standing Order was passed that, in all public lines of railway, the width between the rails was to be 4ft. 8½in., and the Acts for that railway and for the Grand Junction and the London and Birmingham specified accordingly. Whether by accident or design we do not know, but the Act of 1834 for the London and Southampton made no mention of the intended width of the gauge. The Great Western Bill of 1834—which was rejected—specified a gauge of 4ft. 8½in., but when, as related in Article XIV of October 3rd, 1924, of our series "One Hundred Years of British Railways," Brunel wanted a gauge of 7ft., he pointed this omission out to the then Lord Shaftesbury, at that time the Chairman of Committees of the House of Lords, and that was considered sufficient precedent for the width of gauge not to be mentioned in the Bill that became the Act of 1835. The sequel may be seen in the further remarks of Nicholas Wood to the effect that "in 1836, this Standing Order was suspended and there is now no standard of width whatever in any of the railway Bills which pass the legislature, and it is therefore left to the discretion of the railway companies or their engineer of what width the railway shall be constructed."

Miscellanea.

AN interstate oil compact programme for the control of crude oil production has been launched in the United States.

TRANSMISSION on the thirty-line television system by the B.B.C. has been concluded and there will be no further television broadcasts until the new Alexandra Palace station is ready.

THE 500 miles motor car race at Brooklands on Saturday last was won by Messrs. J. Cobb and T. E. Rose-Richards, driving a Napier-Railton at an average speed of 121·28 m.p.h.—a record for this race.

EXTENSIONS to the Barton power station, to cost £470,000, are to be made by the Manchester Corporation. The Electricity Committee decided to seek powers from the Electricity Commissioners to borrow the necessary sum.

A COMMITTEE is to be appointed by the Government to examine the proposal to establish a gas grid in the West of Scotland, to dispose of the by-product gas which will be produced by a number of concerns contemplating the erection of coke oven plants.

IN connection with the United States Government's scheme to plant belts of trees throughout the country to prevent soil erosion, the nurseries established by the Federal authorities will have an output of 600,000,000 trees during the coming year.

ACCORDING to recent figures the electrification of the Italian Railways has resulted in an annual saving of about 1,100,000 tons of coal. A further annual saving of some 230,000 tons is expected when the lines between Florence and Rome and Rome and Naples are electrified.

ACCORDING to Continental reports, an agreement has been practically reached between France and Italy whereby work on the Mont Blanc Tunnel will shortly be begun. The tunnel, which will be about 12 miles long, will be completed within five years, and be intended primarily for motor car traffic.

IN a recent article in the *Industrial Chemist*, for the analysis of nickel-aluminium-iron alloys, Mr. E. C. Pigott recommends the removal of the iron by cupferron, precipitation of the aluminium by aqueous ammonia and its determination as Al_2O_3. Nickel is determined in the filtrate by the dimethyl-glyoxime method.

THE Coal Utilisation Council has set aside some thousands of pounds to finance research into methods of eliminating smoke from the domestic grate. This research, which has already been begun, is being carried out in collaboration with the Government Fuel Research Station, and a number of devices for reducing or preventing the smoke from bituminous coal burnt in domestic appliances have been submitted for consideration.

IT is announced by the Physical Society that the seventh annual Craftsmanship and Draughtsmanship Competition will be held as usual in conjunction with its annual Exhibition of Scientific Instruments and Apparatus in January next. Competitors must be in the regular employ of a firm or institution which will be exhibiting or has exhibited at least once during the previous three years, and which has been invited by the Organising Committee to enter its employees for the competition.

AN extract in the *Iron and Coal Trades Review* describes the work of Mr. F. Eisenkolb on the determination of the comparative loss in weight of mild steel plates in short-period corrosion tests during which the samples were exposed alternately to acid vapour, water and air, and compared with corrosion effects in the open air. The effect of the degree of impurities, the carbon content, the addition of 0·07 to 0·64 per cent. of copper and of molybdenum to 0·08 per cent. were also studied. Measurements were made of the diminution in tensile strength with advancing corrosion.

THE Minister of Transport has made a grant from the Road Fund towards the cost of widening part of the Colwyn Bay-Abergele road, a link in the Chester-Holyhead trunk route. Two lengths of the road have been widened and reconstructed at a cost of about £36,000, and a new viaduct, estimated to cost £13,000, is nearing completion. It is proposed to continue the widening from the new Penmaenhead Viaduct to Wynnstay Road—about 670 yards. The scheme is estimated to cost nearly £40,000, bringing the total expenditure on the three sections up to about £89,000.

THE Geneva correspondent of *The Times* states that at a meeting of representatives of the Cantons of Valais, Vaud, and Geneva recently at Brigue it was decided to ask the Federal Government to convert the second Simplon Tunnel into a road tunnel. It is estimated that one tunnel is sufficient for railway traffic, so that the second could be used for motor cars. That would make it possible to maintain constant road connection through the Alps between Switzerland and Italy. It will be remembered that the Simplon Tunnel consists of two parallel borings, 56ft. apart, the first of which was completed in 1906 and the second in 1922.

AN examination was recently made by the U.S. Bureau of Standards of a hollow cylindrical steel forging used as a reaction chamber for the high-pressure synthesis of ammonia. After approximately eight years' use the cylinder was withdrawn from service as a precautionary measure, and the examination was made in order to determine to what extent the steel had deteriorated in this service, namely, contact with hydrogen and nitrogen under a pressure of several hundred atmospheres and at a temperature of approximately 150 deg. Cent. The tensile properties of the steel (2·54 per cent. chromium, 0·24 per cent. vanadium) close to the inner wall of the chamber did not differ from those of the steel in the centre of the section (2½in.), and were identical with the results reported for the forging when it was made. The only suggestion of deterioration was a decarburised layer, 0·01in. to 0·03in. thick, on the inner wall of the chamber, which, however, was too shallow to have any significant weakening effect on the strength of the cylinder. Other than this, there was no evidence of deterioration in the steel from the service to which it had been subjected.

Air and Water.

THE Board of Trade announces that the Chinese Government has acceded to the International Load Line Convention, 1930. The Convention will become operative in China on November 19th.

A BILL has been passed by the Egyptian Government for the enlargement and improvement of the Port of Alexandria. It is stated that the Government is consulting Sir Cyril Kirkpatrick on the matter.

THE Holland-Dutch East Indies air service has completed its fifth year of service and during this period 250 flights have been made in both directions, the distance covered being approximately 4,500,000 miles.

A FRENCH four-engined mail aeroplane has made a record flight across the South Atlantic from Dakar, Senegal, to Port Natal, Brazil, having covered the distance in 13 h. 37 min., at an average speed of 140 m.p.h.

AN order for ten of the most recent type of "Fury" fighter aeroplanes has been placed with Hawker Aircraft, Ltd., by the Yugoslav Government, which also intends building more machines of this type under licence in its State factories.

A NEW wireless station has been brought into operation at Bristol municipal airport. The station provides a communication and direction-finding service for all aircraft, and will have the call signs GJB for wireless telegraphy and "Bristol" for telephony.

ACCORDING to reports from the U.S.S.R., a military aeroplane made a continuous flight of 900 miles by refuelling in mid-air from a glider which it was towing. The machine flew from Moscow to Koktebel, in the Crimea, a distance of more than twice its normal range.

A RECENTLY issued decree in France authorises the expenditure of an additional £1,105,000 by the French Air Force during the current financial year. The money is allotted as follows:—Works and installations, £520,000; running expenses, £520,000; and schools, £65,000.

THE Mersey Docks and Harbour Board has decided to put in hand immediately the extension, for about 1800 yards seawards, of the training banks on both sides of the Queens Channel. It is expected that completion of this work will be effected in about twelve months.

THE War Department has now disposed of 8½ miles of the Royal Military Canal on Romney Marsh. The Canal was built 130 years ago as a form of defence against the threatened Napoleonic invasion. The Canal has been used for trade and for sporting events, and is now the main drain of the Romney Marsh Catchment Board, which will continue its upkeep.

IN his Presidential Address before the Institute of Marine Engineers, Mr. M. E. Denny stressed the difficulties of increasing the speed of cross-Channel ships. He pointed out that to cut 5 minutes off a run of 60 minutes meant a speed increase of 8½ per cent. This called for a rise of about 60 per cent. in the power, allowing for an increase in the weight of the machinery.

A NEW and "in line" type of air-cooled engine, which is being introduced in the Royal Air Force, will be known as Dagger III. It has twenty-four cylinders arranged in four banks of six, and the banks are disposed in "H" form. The original Dagger engine was tried in a Hart day bomber and the new series will be installed in the Hector biplanes which are being built for Army co-operation work.

AT present there is no uniform method of training officers for the merchant service, and there has been prepared by a Central Board set up by the Shipping Federation a standard system of training. Fifty-five shipping companies have signified their intention of following the Board's recommendations, and it is hoped that eventually all shipowners employing apprentices and cadets will follow the standard system.

SOME large commercial machines are being built for Air France, and, according to *Flight*, the largest, so far as is known, is the commercial version of the Farman F.220 long-range heavy bomber now in series production for the Armée de l'Air. There will be accommodation for forty passengers, the seats being arranged in pairs on each side of a central gangway. Structurally, the type will be a high-wing braced monoplane with four 1000 h.p. Hispano-Suiza "14 Ha" two-row radials, two driving tractor air screws, and the others functioning as pushers. The undercarriage will retract into the engine nacelles and the maximum speed is expected to be 186 m.p.h.

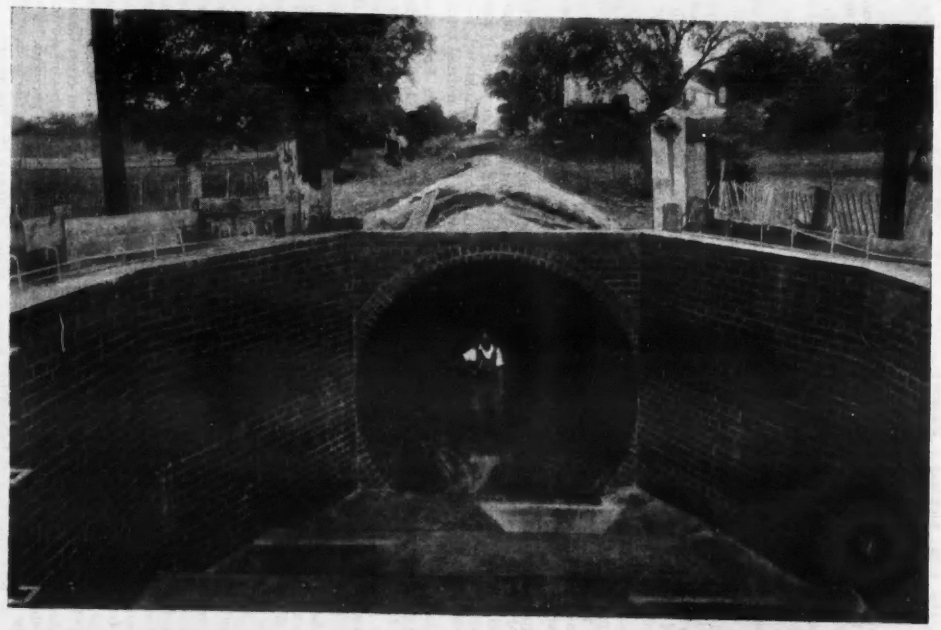
THE search for the motor ship "Joseph Medill," which is some weeks overdue, has been abandoned. This twin-screw motor ship was built by Swan, Hunter and Wigham Richardson, Ltd., to the order of the Quebec and Ontario Transportation Company, Ltd., for service on the Canadian lakes and canals. She was built to specifications and plans supplied by the owners; her construction and scantlings were arranged by them with Lloyd's Register, and she was built under Lloyd's Register special survey. The hull was entirely welded instead of riveted, this being particularly advantageous for a Lake vessel because of the saving in weight. The "Joseph Medill" was said to be the largest all-welded ship, and when completed the owners obtained permission for her to sail across the Atlantic to Toronto without wireless, leaving the Tyne on August 10th.

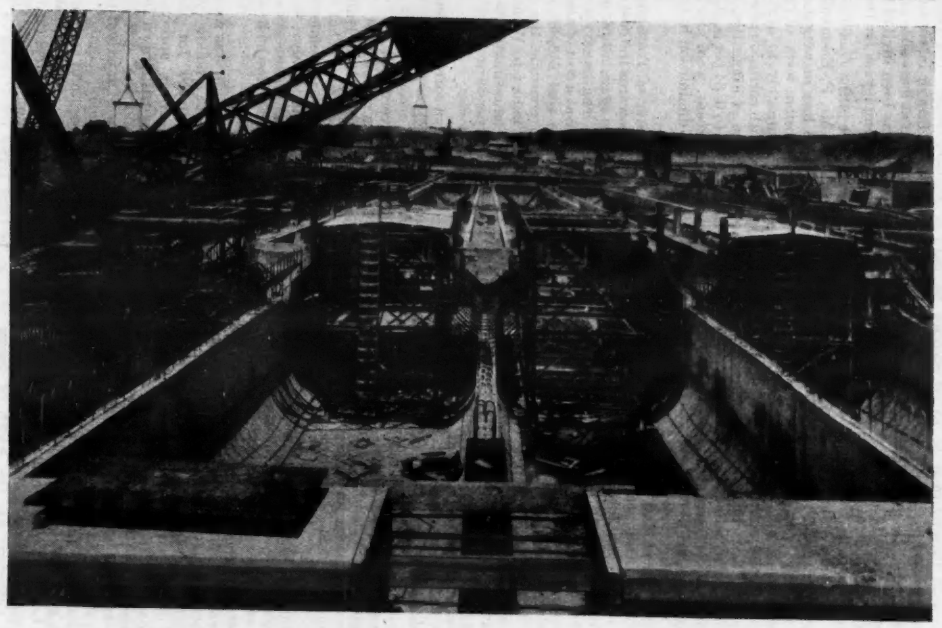
A NEW type of coupling device for coupling up the power delivered by an exhaust turbine to the power supplied by a reciprocating steam engine was recently demonstrated at the Neptune Works of Swan, Hunter and Wigham Richardson, Ltd. The new coupling, instead of depending upon the flexibility of a shaft which can only flex to a limited degree, allows movement of the shaft and perfect running of the coupling. During the demonstration the shaft was deliberately put out of alignment by ¾in., and those attending the demonstration had the opportunity of seeing it work at about the normal engine revolutions achieved by a motor-driven installation. The coupling consists of three discs connected by sliding keys, and when the shafts are in perfect alignment rotation takes place without any relative movement of the keys, but as soon as one of the shafts wears down the movement on the keys prevents the setting up of rocking stresses.

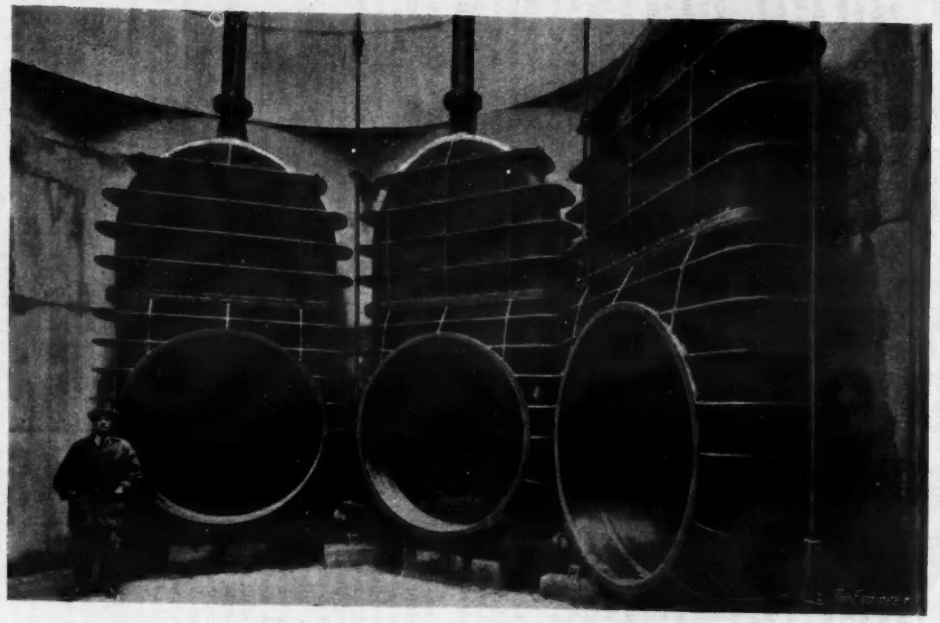
WEST MIDDLESEX SEWERAGE SCHEME—CONSTRUCTION OF WORKS

MESSRS. J. D. AND D. M. WATSON, WESTMINSTER, CONSULTING ENGINEERS

(*For description see page 326.*)







ABOVE:—CONCRETE SEGMENT TUNNEL FOR 10-FOOT DIAMETER SEWER
BELOW:—ACTIVATED SLUDGE AERATION TANKS UNDER CONSTRUCTION

ABOVE:—10-FOOT DIAMETER SEWER AND INTAKE TO BRENT SYPHON
BELOW:—6-FOOT DIAMETER EFFLUENT CONTROL PENSTOCKS UNDER ISLEWORTH AIT

The Engineer

SEPTEMBER 27, 1935.

VOL. CLX. No. 4159

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*** *Will subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses,** *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

UNAPPLIED SCIENCE.

THERE is a story of a scientific man who, after having discovered a new mathematical theorem, laid aside his work with the remark, "Thank Heaven no one will ever be able to put that to any practical use." Whether the story be true or not, there can be no doubt that much of the finest intellectual work of the world has been done simply for the gratification that it afforded to its authors and without regard to any material benefit that they or others might derive from it. To have disentangled some new truth from a mass of seemingly irrelevant facts, or to have discovered some unforeseen relationship between well-known phenomena, can give to certain minds a feeling of satisfaction which is ample compensation for all the labour involved. Work of this kind, carried out merely in the desire for knowledge, is called pure science, and there is a general belief that its results are destined, sooner or later, all to be turned to the use and convenience of man. The pursuit of pure science is, indeed, frequently advocated on these grounds alone. Since any advance in scientific knowledge may perhaps be given some useful application, it is always well to consider the possibility of taking advantage of it; but it is sufficient to say that no other justification is needed for pure science than the intellectual pleasure it affords. If and when its discoveries are found to have a bearing on practical life, by guiding us toward a better utilisation of the resources of Nature or a wiser regulation of our social conditions, we may accept the benefit and be thankful.

To assert that all knowledge will be ultimately useful is to make an assumption for which there is no foundation but a simple faith. Consider how multitudinous are the discoveries for which no practical application can yet be found. One may leave out of consideration such things as mathematical verities which can only be expressed symbolically, but the propositions of geometry which deal with visible magnitudes provide a remarkable collection of abstract knowledge that has never yet been translated into a concrete form. This is the more surprising when so many of the propositions have an obvious kinship with possibly useful mechanisms. Some of the theorems are already centuries old, and must have been pondered over by thousands of men alert to seize on any chance of turning them to practical account, yet in the great majority of cases they have remained unfertile. It may be that the knowledge that the sub-normal of a parabola is of constant length inspired the inventor who sought to make a certain type of isochronous governor, and the fact enunciated by De la Hire in 1666 that, with 2 : 1 circles, a hypocycloid becomes a straight line, may have led Matthew Murray to construct an engine with a straight-line motion based on that property. Again, the use of elliptical gear wheels to obtain the quick-return motion of some old slotting machines may have had its origin in geometrical considerations, while geometrical knowledge has undoubtedly played a leading part in the design of gear teeth themselves. Further instances will occur to the mind, but after taking them all into account, one has merely to glance through any treatise on geometry to realise how few of the innumerable propositions have borne recognisable fruit in the domain of mechanics. Some of the theorems of geometry, indeed, seem almost ready for direct application. Consider, for example, the ordinary indicator diagram, either theoretical or otherwise. There are possibly no curves more widely studied by engineers than the expansion curves of such diagrams, which are employed in connection with the design of engines and compressors of every kind. For practical purposes their equation is always taken to be of the form $PV^n = a$ constant, and the interest lies in the value to be ascribed to the index. Now, geometry teaches us that in every curve of the above family, the numerical value of the index is the same as the proportion which exists between the lengths of the two ends of any tangent terminating on the axes of the diagram. Furthermore, it obviously follows that, in the particular case of a pure adiabatic expansion, the ratio between the specific heats of the working fluid is the same as that which exists between the two parts of the tangent line. These relationships are rarely if ever mentioned in the text-books, and so far as we know, have never been put to practical use. Again, amongst the theorems of less immediate concern with actual engineering is the remarkable discovery of Pascal that, if any irregular hexagon be inscribed in a circle, or, indeed, in any of the other conic sections, and if its opposite sides be extended, the three points at which they intersect will always lie in a straight line. One would imagine that so curious and interesting a property must have some bearing on the design of mechanisms, but up to the present it serves no purpose beyond giving intellectual delight to the mathematician. There are, moreover, hundreds of other perhaps equally striking results of scientific investigations which have just as little bearing on everyday life. They range from purely geometrical properties, some of which may eventually be taken advantage of in the designing of machinery, to achievements of abstract reasoning about more or less incomprehensible subjects. The more one reflects upon the vast and growing accumulation of scientific knowledge the less seems the probability that most of it can ever have any influence on the material welfare of the human race. Indeed, the more profound the investigations into such matters as the properties of space and time, the further are the results removed from practical questions. Fortunately, as we have already said, science needs no utilitarian stimulus. So long as human beings retain their curiosity and their reasoning powers, the frontiers of knowledge will be continually extended, regardless of whether anything more gross than intellectual fruit is to be gathered by the adventure.

We should be sorry if any of these remarks were taken to imply that progress in a material sense is only to be expected from investigations carried out with a utilitarian end in view. We would rather insist on the point that an examination by practical men of the mass of knowledge accumulated—one may almost say buried—in little-read treatises on pure science may possibly bring to light many things capable of being turned to useful account. Facts, such as those of geometry and mathematics, never get out of date. Every advance in general knowledge brings forward fresh facts and new possibilities to which some ancient theorem may perhaps be fruitfully applied. If so, the abstract science of some dead-and-gone philosopher will have been justified at long last by its practical results, and the confidence of those who believe that all knowledge must eventually have such results will have been strengthened. This belief, though probably erroneous, is at least harmless. It may indeed be productive of good if only it encourages those who profess it to seek practical employment for the hitherto useless verities with which scientific literature is filled. There is in such literature an almost inexhaustible mine of ascertained facts and relationships waiting for exploitation. Any one of them, when examined by a sufficiently expert eye, may be found to contain the key to some pressing problem, or to provide the material needed for some further intellectual advance. Many, moreover, are worth studying if only for their intrinsic interest. We have to live in accordance with natural laws, and, generally speaking, human welfare has increased in proportion to our mastery of them. It does not follow that every one of them can be made to serve some material end, but it would be surprising if, in the multitudes of unused scientific facts now at our disposal there are not many which merely await a true appreciation of their import, to enlighten and clear the path for further advance.

Science and Road Traffic.

ON another page we report a discussion on "The Applications of Science to the Control of Road Traffic," which occupied three hours, and then remained unfinished, at a meeting of two sections of the British Association. The discussion attracted an unusually large audience, and we have no doubt that our report of it will be read by nearly all our subscribers. And it ought to be, for it is the concern of every person in the realm to do whatever may be done to bring about not alone a reduction of road casualties, but means of employing our road system to the best advantage. From a very natural, and very human cause, the prevention of accidents to life and limb has attracted the particular attention of investigators. But it is sometimes forgotten that many such accidents are a symptom rather than a disease, and that a radical cure of them is not to be effected so much by road regulations, on which many people pin their hopes, as by improvements in vehicle design, and in the construction of roads, the replacement of dangerous surfaces, better lighting at night, the removal of road glare by day, the segregation of different kinds of traffic, and several allied developments. Admittedly, the symptom must be attacked whilst a radical cure is being sought, but, at the same time, we must not allow superficial remedies to hinder the pursuit of permanent cures. To give an example. A psychological test which examines the rapidity of the reaction of a driver to road-skid and the consequent exclusion of all non-reactive drivers from the road would, were it practicable, lead to a slackening of the effort to discover the perfect non-skid surface. Briefly, there are two directions in which we may bend our efforts. One, the breeding of a race of drivers who could meet with safety any emergency; the other, the removal as far as is practicable by the application of technology of causes which produce such emergencies. It is not necessary to indicate which of these alternatives is the better.

It might, in view of the attention which is being given to the lay-out and form of roads, and to the advances that are being made in road lighting, and, at any rate, sought, in the nature of road surfaces, be thought unnecessary to stress this distinction. Yet much that was said in the British Association discussion shows that unless the better plan is kept constantly in view the less good may be pressed to undesirable limits. Perhaps a remark made by Sir Josiah Stamp is not to be taken *au pied de la lettre*, but it does indicate a conclusion to which the study of accident statistics alone might lead. He hinted at the thought that the total number of accidents was a kind of "sociological constant," and as speed, the number of users, and the number of risks taken increased, so the number of accidents increased. There is very little doubt that statistics would confirm, and in so far as they go do confirm, that that is just what is happening. Probably a "sociological constant" could be found for existing conditions. But if we can alter the conditions we can change the constant. Indeed, we can imagine, if we cannot realise at present, conditions so perfect that the constant would disappear almost entirely. Consider, again, some remarks contributed by the Assistant Commissioner of Police, Scotland Yard. He mentioned "a very narrow, tortuous and difficult piece of roadway in the vicinity of London, for which a by-pass had been demanded, but unless that by-pass had duplicate

carriageways, separate cycle tracks, good pedestrian pathways, completely signalled junctions and so on, it was likely that casualties would be almost increased rather than reduced by the provision of a by-pass. The reason was that the old tortuous road was so dangerous as to be safe, for no class of user dare take any liberties on it." Here we have the two aspects to which we are referring presented in a nutshell. On a Tony Lumpkin's "damn'd long, dark, boggy, dirty, dangerous way" safe driving depends upon the psychology of the driver. The danger is so great that he is compelled to drive with extreme caution. The alternative is a road made as perfect in itself and its ancillaries as man can make it, and the consequent reduction of the call upon what we may describe as the psychological alertness of the driver. There are many people who hold the view that the improvement of roads is the cause of accidents. In a sense they are right, but the only thinkable cure is not the reduction of roads to the Tony Lumpkin standard, but the further improvement of roads and of the vehicles that use them. In all this we are assuming that the driver who drives dangerously from pure recklessness can be and will be eliminated from the roads.

Since, for the debate, Section G (Engineering) united with Section J (Psychology), the psychological aspects of road accidents had to be considered, and they were ably presented by Dr. C. S. Myers. Those who read our report of his speech can scarcely fail to make the reflection that psychology is being extended to include matters which hardly call for the employment of such a dignified and scientific name. Apparently, anything which involves the human factor is nowadays dubbed psychological. Hence Dr. Myers claims the form of traffic signals, road illumination, car signals, and car controls, as coming within his province. But surely such details can be studied in the light of common sense and common experience, and most of them fall directly within the province of the engineer, mechanical, or civil, or electrical. We should be sorry to think that engineers were waiting upon psychology to tell them what they ought to do, or ought not to do, with regard to such practical problems as the position or form of light signals, the lay out of roads and the improvement of their surfaces, or the modification of the controls fitted to vehicles. In the dictionary sense psychology is "the science of mind; systematic knowledge and investigation of the genesis, powers and functions of mind." The scope of the word has been extended to include all human reactions, voluntary and involuntary, and we may therefore leave to the psychologist the examination of the physical and mental fitness of drivers. But the removal from cars of all elements which may provoke accidents and the introduction of devices and improvements—braking and lighting, for example—which tend to reduce accidents, is the duty of the motor vehicle engineer, just as the improvement in the lay-out of roads, the provision of banking where necessary, and the perfection of a non-skid, non-glaring surface is the duty of the civil engineer. Enormous advances both in the vehicle and the road have been already effected, but much remains yet to be done. No one will question that by concentrating their attention on these objects engineers may bring about as great a reduction in road accidents as genuine psychological progress, like the breeding of a "how to cross the road sense" in children, can ever accomplish by itself.

The Iron and Steel Institute.

No. II.

(Continued from page 301, September 20th.)

Sixth Report on the Heterogeneity of Steel Ingots.

THE first business of the meeting was the consideration of the Sixth Report of the Committee on the Heterogeneity of Steel Ingots. We give below a few points from the Introduction to the Report, which itself occupies over 200 pages of the "Proceedings."

The work of the Committee continues, and in this, the sixth Report, the results of further investigations and of the further consideration of interesting features of the problem are presented for the consideration of the members of the Institute.

In November, 1934, the Committee sustained the serious loss of Mr. J. H. S. Dickenson, Vice-Chairman, whose death occurred very suddenly. From the commencement of their work, Mr. Dickenson had a great influence in the deliberations within the Committee and contributed heavily to the common fund of experimental data. As his published work will reveal, Mr. Dickenson had done much in early years to help to lay the foundations upon which the Committee still endeavours to build, and this opportunity is taken to place on record the indebtedness and appreciation of his friends and colleagues.

At the unanimous invitation of the Committee, Dr. T. Swinden was asked to succeed to the position of Vice-Chairman.

Dr. A. McCance, Mr. H. H. Burton, Mr. E. C. Evans, Mr. R. A. Hacking, and Mr. W. T. Griffiths have accepted invitations to join in the work of the Committee.

Sir Harold Carpenter, F.R.S., resigned his membership of the Committee on his election as President of the Iron and Steel Institute. The Committee are glad to be able to report that he intends to maintain his close interest in their work.

The Committee have been at work since 1924, and the nature and contents of their Reports, including the present Sixth Report, reveal very clearly the vast amount of further experimental work which is really necessary for a satisfactory progressive development of the subject. At the outset the Committee realised that it was essential:

(1) To have exact pictures of the heterogeneity of ingots cast from different steels, made by various processes, under different conditions and forms of technique.

(2) To know how the experimentally observed result had been produced with such accuracy that repetition could be satisfactorily achieved industrially.

(3) To know *why* the particular procedure produced the observed result.

As regards (1) it will now be observed that sixty-nine ingots have been studied, varying in weight from a few hundredweights to over 170 tons, covering a wide range of compositions, and cast from steel made by different processes. As time has passed the Committee have endeavoured to make the records of each case as complete as possible, although finality has by no means been attained in this direction. As regards the examination of the various ingots, a uniform system has been followed from the commencement of the work, *i.e.*, the examination of the plane exposed by sectioning along the longitudinal axis; sulphur prints and macro-etchings have been presented together with analyses taken at the critical positions which were originally decided upon. It has been found necessary to amplify the data originally determined by adding data showing the distribution of oxides and silicates, oxygen, nitrogen, and hydrogen. It is realised that the method of presenting the determination of the composition as a result of averaging the material removed from the section by means of a drill of substantial dimensions (size ¼in. to 1in. in diameter), leads to the figures being average ones over a certain volume of material, and this has to be taken into account in evaluating the results for theoretical purposes. With the aid of such results, it can be said that the large-scale heterogeneity has been pictured with useful accuracy in the large number of ingots studied. This work will be continued on other examples. The need for a study of heterogeneity on a smaller scale has led the Committee to extend their work with the microscope.

It is fair comment that this part of the work follows natural history methods, but no other procedure is permissible or available for laying a sound foundation for the researches.

With regard to (2) it can be said with truth that ability to reproduce a given result is only possible, in perfection, if the full details of manufacture are quantitatively recorded with accuracy. Here the Committee are in somewhat of a dilemma, since it is a matter of extreme difficulty even to enumerate and to schedule all those factors which may or may not have an influence on the result. However, having determined the data which are desired, it is not always practicable or possible to obtain the necessary quantitative record—for instance, temperature determinations, and, until now, figures as regards oxygen content. Much of the Committee's deliberations has been of late on these particular problems.

With regard to (3), as to the why and wherefore, the Committee feel that, in spite of their early attempts in this direction, much further fundamental knowledge is required. Progress with (1) and (2) will result in direct technological advance, whilst (3) is a matter of intellectual satisfaction, and also of inestimable practical value if and when achieved.

The present Report is composed of the following sections:—

Section I.—Introduction.

Section II.—The Examination of Further Ingots and other Experimental Work by the Committee.

Section III.—The Origin and Formation of Inclusions, by Professor J. H. Andrew, D.Sc., Mr. T. Raine, and Mr. S. B. Vickers.

Section IV.—A Critical Examination of the "Vacuum Fusion" Method for the Determination of the Total Oxygen in Steel, by Mr. H. A. Sloman.

Section V.—Bibliography on the Determination of Oxygen in Iron and Steel, by Mr. R. Elsdon.

Section VI.—A note on the Determination of Nitrogen and Some Results, by Dr. T. Swinden and Mr. W. W. Stevenson.

Section VII.—Bibliography on Nitrogen in Iron and Steel, by Mr. G. C. Lloyd.

Section VIII.—Some Experiments on Gases in Iron and Steel, and their Effect on the Solidification of Ingots, by Dr. T. Swinden and Mr. W. W. Stevenson.

Section IX.—The Mechanical Properties of Carbon Steels melted *in Vacuo* and in Certain Gases, by Professor J. H. Andrew, D.Sc., and Mr. H. Elliss.

Section X.—Segregation in Steel Ingots, by Professor J. H. Andrew, D.Sc., and Mr. E. M. Trent.

Section XI.—The Influence of Casting Temperature upon the Position of Blow-holes in Steel Ingots of Varying Oxygen and Carbon Content, by Principal C. A. Edwards, F.R.S., Dr. R. Higgins, Mr. M. Alexander, and Mr. D. G. Davies.

Section XII.—The Constitution of Steel and the Influence of Differential Solidification upon Segregation in Steel Ingots, by Dr. L. Northcott.

In Section II will be found the account of the Committee's further study of commercial ingots. During the period subsequent to the publication of the Fifth Report several more ingots have been critically examined:

Rimming Steel.—Examples 63 and 64, two ingots of rimming steel made by the basic Bessemer process. Example 65, an ingot of rimming steel of high purity made by the basic open-hearth process.

Killed Steel.—Example 66, an ingot of 18/8 chromium-nickel Staybrite type acid-resisting steel. Example 67, several ingots of austenitic 13 per cent. manganese steel. (Owing to the difficulty of preparing the ingots, the forged blooms instead were subjected to a similar examination.)

Steel Incompletely Killed.—Example 68, an ingot of special steel low in carbon, silicon, and manganese.

Centrifugally Cast Steel.—Under Example 69 two experiments on the centrifugal casting of steel are described.

Discussion.

Dr. W. H. Hatfield, the Chairman of the Committee, introducing the Report, made reference to the work of Professor Andrew, Dr. Desch, and their colleagues, with a view to determining the correct percentage of oxygen in steel. An accurate quantitative knowledge of oxygen content, he said, was fundamental to any further progress, but it could hardly be claimed at the moment that the oxygen content was known absolutely; there remained a trifle of sorting out to be done.

Reference was also made to the fact that, through the courtesy of one of the Continental members, the Committee had had the opportunity of examining basic Bessemer rimming steel made there. Members of the Committee had visited the works to follow through the technical details of the production of the ingots. In common with other ingots examined, they had very distinctive features. The members of the Committee had racked their brains in an endeavour to deduce some logical explanation of the phenomena in rimming steel, and there had been developing gradually an explanation depending upon a reaction taking place in the liquid steel between the carbon and the oxygen content in the metal, immediately in juxtaposition to the advancing solidifying wall, with the evolution of gas. But whatever theory was advanced to explain the phenomena associated with the rimming steel ingots, we must explain why, as shown in two sulphur prints he exhibited of the Continental basic Bessemer rimming steel ingots, the rim was virtually pure and as solid at the top of the ingot, where it was frozen in the atmosphere, as at the side and bottom, where it was frozen from the metallic surface of the mould.

Professor J. H. Andrew (Sheffield) presented the section of the report with which his name was associated. With regard to Section X, dealing with segregation in steel ingots, he pointed to a theory put forward there, which might appeal to some. The intention was to try to explain the major segregation occurring in large ingots. He referred to an ingot of 175 tons, referred to in the Committee's First Report, where the carbon content at the bottom was about 0·143 per cent. and at the top about 0·58 per cent. The view was that differential solidification—the occurrence of which was an established fact—could not alone account for the migration of such large amounts of carbon, phosphorus, and sulphur as had migrated from the bottom of the ingot to the top centre position. He suggested that there was differential solidification and a concentration of iron oxide and carbide of iron in the interstitial spaces. When the concentration reached a certain value a reaction occurred, with the formation of carbon monoxide. The pressure of that gas would develop to a certain extent and would blow out from the interstitial spaces the impure substances which had segregated owing to differential cooling. Obviously, when the impurities were blown out, voids were left, and provided that in contact with the void there was a large quantity of liquid metal of more or less normal composition, the liquid metal would flow in and fill up the voids. So that the impurities would gradually move towards the centre of the top part of the ingot.

Commenting on Section IX of the Report, which dealt with the mechanical properties of carbon steels melted *in vacuo* and in certain gases, Professor Andrew said he was beginning to wonder whether the gases which steel makers had been trying to extract from steel were not possibly very useful ingredients in the steel. Was it a mistake to try to extract them, or should there not be left in the metal a certain quantity of gas, which appeared to impart useful properties to it?

Dr. T. Swinden, having presented Section VIII, dealing with experiments on gases in iron and steel, and their effect on the solidification of ingots, was not sure that he would go so far as Professor Andrew seemed to suggest with regard to the desired oxygen content, although one knew the disadvantages of over-reduced steel. But he believed that a stage would be reached of analysing for nitrogen and of having a definite amount present for certain specific purposes, making use of the nitrogen content rather than regarding it as a deleterious constituent.

Principal C. A. Edwards (University College, Swansea), commenting on Dr. Hatfield's observations on the solid pure crust at the top of the rimming steel ingot, said it must be remembered that the gas could be seen rising during the rimming action, and that that proceeded until the solid thick crust was formed; but the reaction stopped (*i.e.*, there was no gas liberated) as soon as rimming ceased. Further, one would expect a relatively pure top (though, he confessed, not so thick as was indicated in the sulphur prints of the Continental ingots), because during the freezing of the solid crust the interior temperature had necessarily been falling, and by the time the crust was bridging over, the rate of solidification would be relatively greater than it was lower down, because the freezing at the top was taking place over a lower temperature range. However, that suggestion was purely tentative, and he would like to think further about it. He also remarked that the Continental ingots illustrated were abnormal; in most rimming ingots there was not such a thick solid wall on the top.

Dr. C. H. Desch also presented part of the Report.

Dr. A. McCance, after questioning whether the rimming steel ingot with the thick crust was really a representative sample, observed that in one part of the Report the assumption was rather indicated, though not definitely made, that skin blow-holes at the feet of rimming ingots were due to hydrogen. He ques-

tioned whether, in the light of present knowledge, such an assumption was justified. In one series the peculiar dog-tooth type of blow-hole was shown as the result of passing carbon monoxide through the ingot; but he believed that type of blow-hole was due rather to the manner of its formation than to the presence of any particular gas. Any type of gas would give rise to that particular type of dog-tooth blow-hole if it were given off at a time when rapid solidification along a particular direction was taking place. Therefore the conclusion that the blow-holes were due to hydrogen should be held in abeyance until evidence for or against had been obtained.

In Principal Edwards' series, also, the lowering of the temperature sometimes produced the skin blow-holes, when other conditions remained as before; if the ingot had been cast at a low temperature skin blow-holes were formed, whereas the blow-holes did not occur when the ingot was cast at a higher temperature, though the same amount of oxygen and of aluminium had been used. Hence temperature was probably a determining feature, and further work must be done before an adequate explanation could be deduced of the occurrence of that rather important type of blow-hole. If such blow-holes occurred too near the surface in sheet bars very rough-looking sheet bars were produced. An adequate explanation and a method of control would constitute a real step forward.

It would appear, from Section XI, dealing with the influence of casting temperature upon the position of blow-holes in steel ingots of varying oxygen and carbon content, that there was gas evolution of two types, one being the rapid evolution when the skin was being formed, and the other the evolution occurring when the central blow-holes were produced. But Dr. McCance considered that those two different effects were produced from the same cause, though under different temperature conditions. It had been stated that, whilst the rapid solidification was taking place, equilibrium conditions were very much displaced and gave rise to very rapid gas evolution; but when that chilling action ceased the rate of gas evolution was slower. Dr. McCance suggested that that, coupled with the lowering of the temperature and also the fact that the carbon reaction absorbed a substantial quantity of heat, were sufficient to cause the very marked difference between the two rates of gas evolution noticed during the solidification of an ingot. That was further supported by the fact that if one had the misfortune to cast a rimming steel with insufficient gas the whole of the gas evolution was of the slow pasty type, which gave rise to a scrap charge or an ingot of which no use could be made.

Dr. W. H. Hatfield, commenting on the references made in the Report to hydrogen causing blow-holes, pointed out, in order to prevent misapprehension, that at the National Physical Laboratory it had been discovered that in the gaseous products of reduction in one of the solid ingots 50 per cent. of the gas was hydrogen. That was an interesting and amazing fact.

The Continental ingots with the thick crust at the top were not abnormal ingots, as had been suggested; they were normal and were typical of millions of tons of ingots produced on the Continent. Replying to Dr. McCance's reference to them, Dr. Hatfield said he regarded the presentation of the data as important for arriving at a satisfactory explanation of rimming steel. It was pointed out in Section II of the Report that the ingots showed signs of freezing when only two-thirds teemed, and a crust of metal had formed in the centre of each ingot by the time the ladle was withdrawn to the next pair of moulds. Moreover, the ebullition in the mould, which was noticeable when teeming acid Bessemer or basic open-hearth rimming steel, was not in evidence, and little gas appeared to be evolved from the stream when leaving the nozzle. The manufacturers considered the effervescing action to be less than usual. So that there was very distinct evidence, he said, that the amount of gas evolved was not as great as was generally considered necessary to produce a rimming steel. He believed that within reasonable time he would be able to convince his colleagues that the rim was more to be attributed to the deposition of the delta phase and less to be associated with the evolution of carbon monoxide gas.

A paper, abstracted below, on "The Fatigue Properties of Patented Steel Wires: II, Note on the Effect of Low-temperature Heat Treatment," by Mr. Gill and Dr. Goodacre, was then presented.

FATIGUE OF PATENTED STEEL WIRES.

Low-temperature tempering of cold-drawn wire is an essential process when the material is used in the form of a spring. The effect of this treatment on the fatigue properties has been examined for four steels of 0·37, 0·55, 0·79, and 0·86 per cent. carbon content respectively, drawn to varying reductions, from 25 to 90 per cent., and tempered in the range 150 deg. Cent. to 400 deg. Cent. The wires were free from decarburisation but not polished. The following points were noted:—

Generally there is an increase in the limiting fatigue strength, the optimum temperature being of the order of 200 deg. Cent. (for one steel, 0·79 per cent. carbon, it was 150 deg. Cent.).

With all the steels examined, there is a critical reduction, at which point under certain tempering conditions the limiting fatigue stress may fall considerably below that for the as-drawn condition. This critical reduction becomes progressively lower as the carbon content increases.

The so-called cleanliness of the steel seems to have a bearing upon the results. The steel with the least amount of manganese, sulphur, and phosphorus present gave the most widely varying figures, while for the steel containing the most of these elements the fatigue limit never fell below that for the as-drawn condition. The results generally support the precipitation theory of hardening.

Fatigue limits as high as $\pm 44{\cdot}9$ tons per square inch were obtained, and it is suggested that if the materials are polished a fatigue limit of the order of ± 55 tons per square inch should be possible.

As far as has been ascertained there is no direct relationship between the usual physical tests (bends, torsions, &c.) and the limiting fatigue stress.

DISCUSSION.

The President remarked that it was unusual for Carnegie Research Reports to be read at the meetings, but the present Report was included because the Council felt that the subject was of outstanding importance.

Mr. H. Sutton (Royal Aircraft Establishment, Farnborough) said that at first sight the work would seem to be an essential asset to those engaged in the production of high grades of cold-drawn steel wires as used for the manufacture of springs of high performance and reliability. The fact that such wires, free from surface decarburisation, were manufactured on a commercial scale reflected great credit upon the firms which had taken up the work, and upon the metallurgists and others responsible for the development of the necessary technical processes.

It was gratifying to learn that cold drawing of the normalised carbon steel wires of 0·37–0·70 per cent. carbon content gave progressive improvement in fatigue properties with increasing reductions of sectional area up to 90 per cent. He asked if the degrees of reduction of commercial importance lay within the range covered by the authors, or whether larger reductions were likely to be required.

The results of the 0·79 per cent. carbon steel would suggest that tempering for high fatigue properties must be conducted with careful reference to the previous drawing operations to which the wire had been subjected, particularly when the drawing had not resulted in very big reduction of section.

Discussing size effect, he said the lower fatigue properties of the wire drawn by moderate reductions from rod normalised at a diameter of 0·232in., compared with those of wires normalised at diameters rather more than 0·080in., and then drawn down to 0·080in., would seem to be due, as the authors suggested, to different response to heat treatment in the two cases. He asked what was the reason for a longer period of tempering in one series than in another.

The meaning of the percentage variations in fatigue ratios was not very clear; perhaps they represented the extent of variation about the mean value. Probably the values of the ratios themselves were of greater interest to those concerned with spring materials than was the percentage variation in ratio, which was a somewhat difficult function to visualise.

Mr. Sutton welcomed the fact that the authors were working on the problem of endurance at stresses above the fatigue limits. That matter was of considerable practical importance as well as of theoretical interest. The study of the shape of the S/N curves was of special interest, and he hoped the authors would bear that in mind when they presented their further work.

Professor F. C. Thompson asked what was the order of accuracy of the authors' experiments and the reproducibility of their results, a fact which was important if one were to attach very much weight to kinks in curves. He also asked whether the authors had determined the extent to which ageing occurred after tempering, and what methods they had found most suitable for the determination of the limit of proportionality, because that was an exceedingly difficult determination to make.

Assuming that ordinary ageing and the changes of properties which occurred on low-temperature heat treatment were in their essentials the same, an assumption which seemed to him to be justified, he said there was a growing body of evidence that the ageing process was not so simple as was at one time imagined. When curves for several ageing operations were drawn faithfully through the experimental points obtained, there was a series of small, but quite definite periodic fluctuations in those curves. In wire drawing, fluctuations of a similar character were obtained, as shown in the work published by Francis and himself on the influence of the die angle; but he had no explanation to offer. He asked if the authors could study a small portion of one of their curves around the critical points, and, by obtaining a sufficient number of points near together, determine whether or not the abnormalities were due to a definite periodicity superimposed on a general smooth curve.

Dealing with the authors' reference to the modulus of elasticity and their statement that they found little or no variation as the result of tempering, he said that generally it was found that the modulus of elasticity was raised quite definitely by a low-temperature heat treatment on cold-drawn wire; he believed there was some ground for the view, though one could hardly regard it as proved, that possibly a higher modulus of elasticity could be obtained from cold-worked and blued steel than from any other ferrous material.

When many of the non-ferrous wires were drawn one did not find any indication of an ageing property. That seemed to put out of court any explanation based on an amorphous material and any based on the presence of internal stresses. One was therefore almost definitely left with the precipitation explanation as the only one which even approximately fitted the facts.

Dr. Goodacre, replying to the discussion, said that the 90 per cent. reduction of area did not come within the limit of practice, or, at any rate, very infrequently. The old wire drawer had always said that 75 per cent. reduction was the limit, but actually one could exceed it. He emphasised the fact that the wire mentioned in the paper was not the ordinary grade wire. The authors were finding that if the decarburisation were removed, the properties of the wire when drawn to 75 per cent. were enhanced as compared with those of wire drawn from decarburised material.

The difference in the tempering times referred to by Mr. Sutton was accidental; but Dr. Goodacre did not think that made very much difference to the results.

The percentage variation of the ratio of limiting fatigue stress to tensile stress was based, for one steel, over a whole series of temperatures and percentage reductions and the variations based on the minimum.

In reply to Professor Thompson, he said the fatigue tests were conducted on the new Haigh Robertson fatigue and alternate bending machine, developed specially for wire. As to the order of accuracy and reproducibility of the results, he said it worked out to within $\frac{1}{4}$ ton per square inch when estimating limiting fatigue strength.

The authors had not considered possible ageing effects, and, having regard to the procedure adopted, he did not see how ageing could come into the results. The limits of proportionality were determined by the ordinary wire extensometer. The variation of modulus of elasticity was so little as to be negligible for purposes of calculation. The authors had had under consideration a study of fatigue curves near one of the critical points.

(To be continued.)

The New P. and O. Liner "Strathmore."

No. II.

(Concluded from page 290, September 20th.)

IN our last article we referred briefly to the large sports and games spaces provided for the first-class and the tourist class passengers. The two upper photographs reproduced on page 326 are views taken on the first-class boat and sports deck, and on the tourist promenade and sports deck aft respectively, and they clearly show the roomy character of these deck spaces.

STEAM GENERATING PLANT.

The lower view reproduced to the left of page 326, shows the main boiler-room, and half sections looking forward and aft are given on page 327.

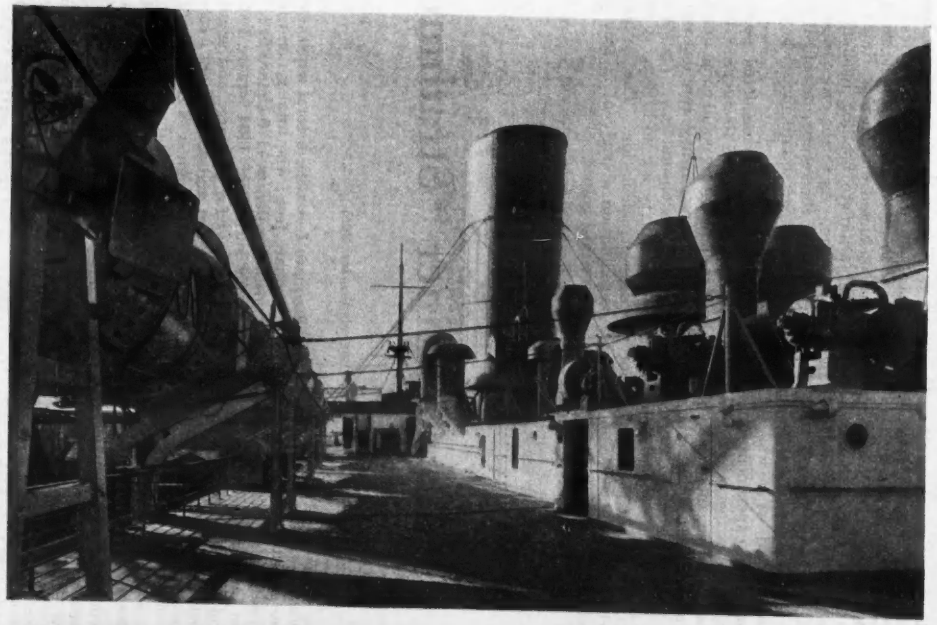
The steam generating installation consists of four and two smaller Babcock and Wilcox high-pressure marine type boilers, all fitted with superheaters and tubular air heaters. The blow-off pressure of the boilers is 450 lb. per square inch, and the steam temperature 725 deg. Fah. The steam drums of the boilers are of seamless steel, and were manufactured by the English Steel Corporation, Sheffield. The total generating surface of the four large boilers is 29,860 square feet with a total superheating surface of 4280 square feet; the total generating surface of the two small boilers is 7170 square feet, with a total superheater surface of 1434 square feet. The air-heating surfaces for the large and small boilers are 32,000 square feet and 8000 square feet respectively.

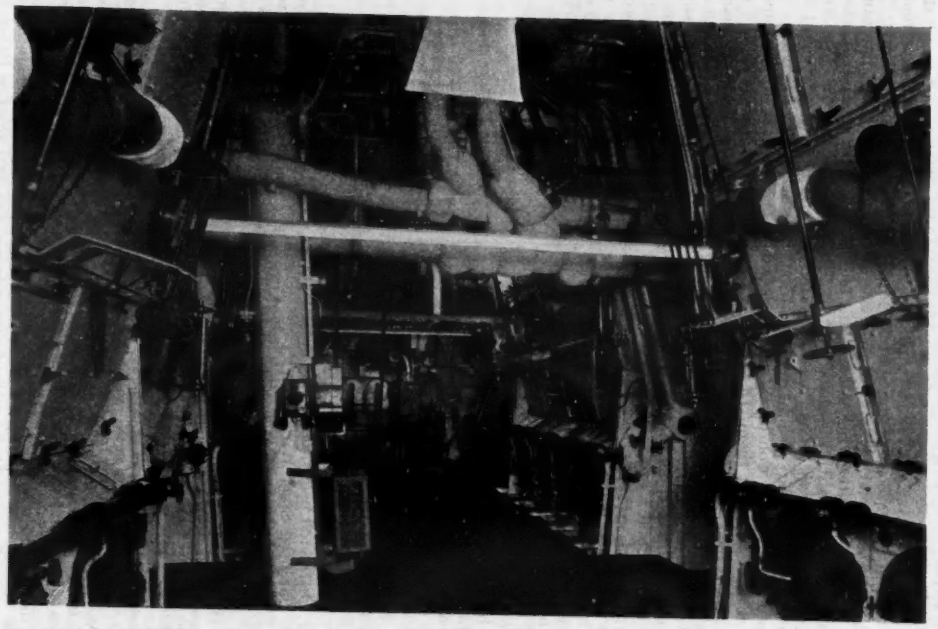
The boilers are designed to burn oil only under the forced draught closed air duct system in open stokeholds. Air is supplied by five double-inlet electrically driven Howden fans. The oil fuel installation consists of four Wallsend units, each comprising one electrically driven pump and one heater; one pair working and one pair standby. Two oil fuel transfer pumps of the electrically driven, two-throw type are provided, each having a capacity of 60 tons per hour for transferring oil to the settling tanks. The tube-cleaning equipment for the boilers and air heaters includes Babcock Diamond type soot blowers. Malone CO_2 recorders are provided for the boiler plant, and Negretti and Zambra's temperature indicators of the thermo-couple type are used for the funnel gases.

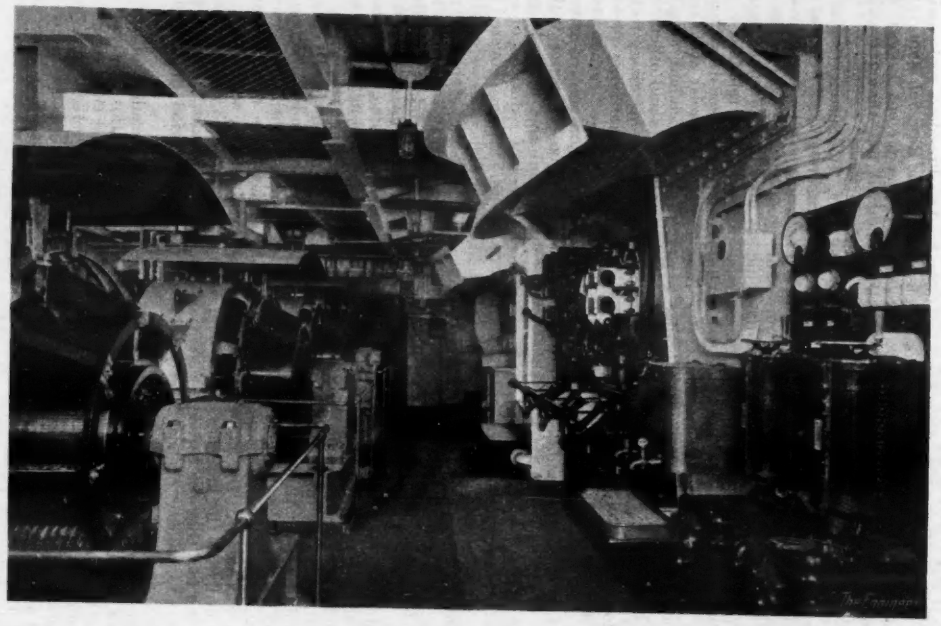
The insulation is of the Newall type, which includes "Newtempheit" high-temperature covering and

THE NEW P. AND O. LINER "STRATHMORE"

VICKERS-ARMSTRONGS LTD., BARROW-IN-FURNESS, BUILDERS AND ENGINEERS







ABOVE:—FIRST-CLASS BOAT AND SPORTS DECK
BELOW:—MAIN BOILER ROOM

ABOVE:—TOURIST-CLASS SPORTS DECK
BELOW:—TURBO-GENERATORS AND SWITCHGEAR

other forms for steam pipes and engine and boiler casings, &c.

ENGINE AND BOILER-ROOM AUXILIARIES.

The engine-room arrangement drawing, reproduced on page 288 *ante*, and the boiler-room drawing below show the position of some of the principal auxiliaries. The main condensers are of the Weir regenerative type and a Weir "closed feed" system, with electrically driven main and auxiliary extraction pumps, is fitted. The main extraction pumps draw the condensate from reservoirs in the main condensers and deliver it through three-stage air ejectors and the drain cooler to the main feed pump suctions.

The feed pumps are of the steam turbine driven type, and are two in number, each designed to deliver 240,000 lb. per hour against a discharge pressure of 550 lb. per square inch, through low-pressure intermediate and high-pressure heaters, to Babcock and Wilcox automatic feed regulators on the boilers. The feed-heating steam is taken from the auxiliary exhaust system, and is also bled at suitable pressures from the main turbines.

There are two Allen main circulating pumps of the turbine-driven centrifugal pattern, each of which delivers 16,000 gallons per minute against 21ft. head, and one Drysdale electrically driven auxiliary centrifugal circulating pump of "upright" type, designed to deliver 1800 gallons per minute against 24ft. head.

The evaporating plant for providing distilled water for the boilers comprises two Weir vertical high-pressure evaporators, each capable of providing 40 tons per day, when supplied with steam at 75 lb. per square inch. The evaporators are fed by two electrically driven two-throw feed pumps, each of 40 tons per twenty-four hours capacity. In addition, there is a fresh water distilling plant for the ship's services. It comprises two Weir vertical evaporators of the high-pressure type, each producing 50 tons of pure fresh water per day, when supplied with steam at 90 lb. per square inch, and two Weir distilling condensers, each capable of condensing 50 tons of vapour in twenty-four hours. One electrical two-throw feed pump is provided for this evaporating plant, with a capacity of 3 tons per hour.

The various service pumps installed in the engine and boiler-rooms include the following:—Two forced lubrication pumps, each delivering 24,000 gallons per hour against 50 lb. per square inch pressure; two bilge pumps, each of 60 tons per hour capacity, delivering against 60ft. head; one fire and bilge pump of 160 tons per hour against 50 lb. per square inch, or 80 tons per hour against 100 lb. per square inch; two sanitary pumps, each of 200 tons per hour capacity against 105ft. head; one wing transfer pump and one bath pump, each of 60 tons per hour capacity against 90ft. head; one bilge pump of 160 tons per hour against 60ft. head; and one emergency S O S type of bilge pump, capable of dealing with 80 tons per hour against 100 lb. per square inch, or 160 tons against 50 lb. per square inch. All the above pumps are of the Drysdale electrically driven centrifugal type.

The steam supply to the turbines passes through Cockburn emergency valves, fitted at the engine-room bulkhead. These valves can, in case of emergency, be closed instantly by hand, and they operate automatically in the event of either a failure in the supply of lubricating oil to the machinery or if the turbine speed rises above the specified figure. The turbines are also automatically stopped in the event of pressure accumulating in the main condensers.

Two auxiliary feed pumps of the Weir steam-driven vertical direct-acting type, with a capacity of 60,000 lb. per hour, one harbour feed filter of the pressure type, capable of dealing with 60,000 lb. per hour, one electrically driven two-throw drain tank pump, fitted with automatic float control of 3 tons per hour capacity, and one electrically driven Vickcen lubricating oil separator of 225 gallons per hour capacity are installed.

For carrying out repairs and adjustments a fully equipped engineers' workshop is provided. In it there are one 7½in. screw-cutting and surfacing lathe, one hand and power-driven drilling machine, one emery grinder, and one grindstone. The machines are driven by a 5 h.p. electric motor.

MAIN AND EMERGENCY GENERATING PLANTS.

The main electric generating machinery consists of three steam turbo-driven, direct-current, compound-wound, dynamos constructed by British Thomson-Houston Company, Ltd., each of 500/550-kW output at 220 volts, placed in an auxiliary machinery compartment forward of the engine-room. A view of this room is reproduced on page 326. The generators are driven at 500 r.p.m. through single-reduction, double-helical gears. The steam turbines, which run at 5000 r.p.m., are designed for a steam pressure of 400 lb. per square inch, and a temperature of 700 deg. Fah., but are capable of withstanding the full boiler pressure of 450 lb. per square inch and a temperature of 725 deg. Fah. They are of the standard B.T.H. impulse type with stainless steel blading.

The emergency plant is an Allen 110-kW set, comprising a six-cylinder C.I. engine, designed to develop 165 h.p. at 600 r.p.m., directly coupled to a 220-volt generator of the single pedestal bearing type. The set is arranged on an upper deck in a separate house, and the engine is started by compressed air stored in bottles in the room, which are kept charged.

ELECTRIC POWER CONTROL AND DISTRIBUTION.

The system of control and distribution of the electric power adopted embodies special features to secure a continuous supply under abnormal conditions, since such vital equipment as the steering gear, engine-room auxiliaries, &c., is all driven electrically.

The main switchboard is fitted in the dynamo room and is split into three separate boards, each fed from its own generator through a 2500-ampère, triple-pole circuit breaker. The bus-bars of the port and starboard boards are linked to the bus-bars of the centre switchboard through two 3500-ampère D.P. switches, fitted on the centre switchboard.

The main dynamo breakers have the usual overload device with time lag and reverse current releases, while the positive and equaliser poles are mechanically coupled for hand control, the negative pole being electrically operated by a solenoid and controlled by a switch conveniently placed for paralleling. In order to maintain the supply in the event of abnormal conditions, special instant-action, emergency overload trip relays are fitted. They operate at a predetermined load to trip out certain selected feeder circuits of secondary importance, thereby relieving the generators of a large proportion of their load. This is desirable in the case of a generator shutting down involuntarily when running in parallel with other generators, thus tending to overload the machines remaining on the bus-bars, with the probability of their breakers being tripped out. A similar risk arises when the running machines become loaded beyond their normal working capacity.

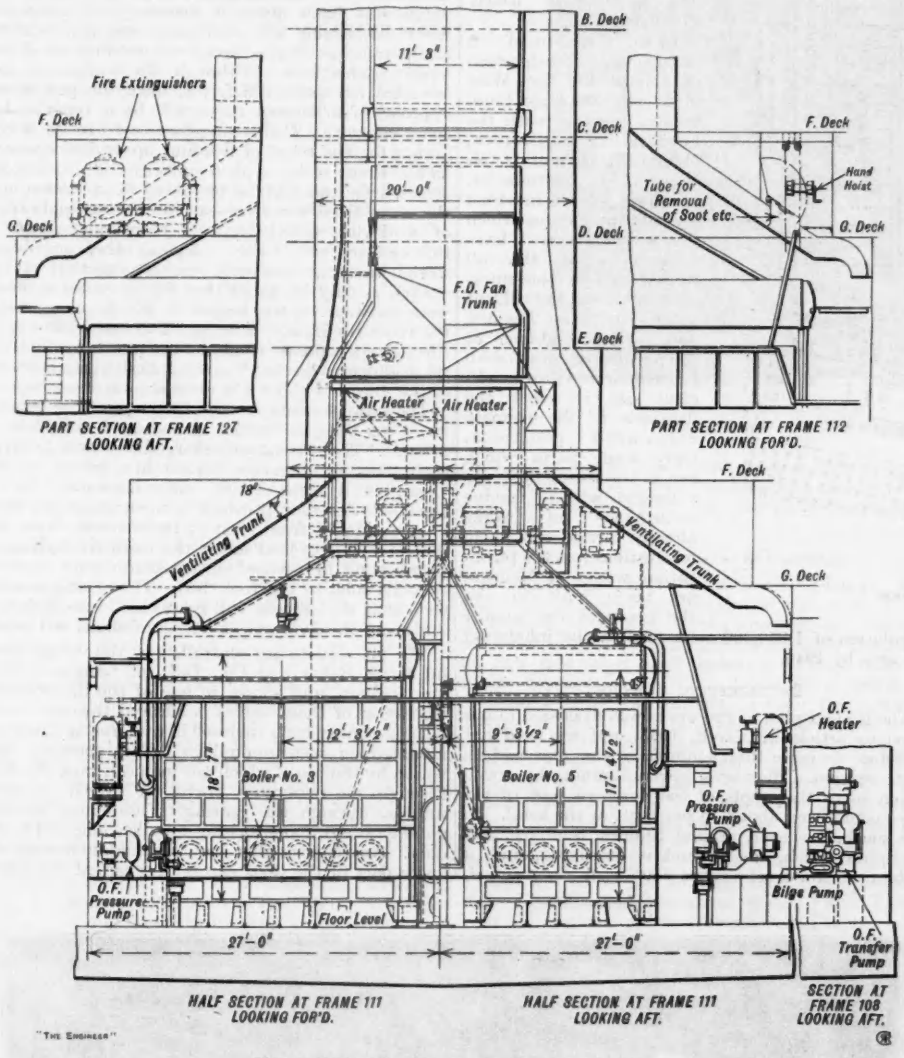
The main switchboards distribute current to thirteen auxiliary switchboards fitted in convenient positions throughout the ship, and also to important power and lighting services, through D.P. circuit breakers or D.P. switches and fuses, as required. All the switchboards consist of substantial slate, black enamelled, which is mounted on steel framework. The switchboards were supplied by Whipp and Bourne, Ltd.

The motors used in the various parts of the ship are generally of the marine type, with enclosed ventilated, drip-proof cases. Each has its own controller or starter, according to its size or to the nature of its service, field regulators being fitted where variable speed is required. For low-voltage circuits associated with the navigation and safety of the ship, such as fire alarms, alarm bells and navigation telephones, two storage batteries are provided, each containing eleven "Exide" M V B 9 cells. Each of these batteries has a capacity of 128 ampère-hours, at the ten-hour rate of discharge. The batteries are charged from the ship's 220-volt system.

REFRIGERATING PLANT.

The main refrigerating plant deals with insulated spaces in the Nos. 1, 2, and 3 holds, and 'tweendecks, and a large set of provision chambers situated on "J" deck, immediately abaft the cargo spaces. The total capacity of the cargo and provision chambers is about 244,000 cubic feet. In addition to the main provision chambers, there are numbers of cold cupboards, water coolers, milk cooler, &c., served by brine from the main refrigerating plant. There are also connections to the air-conditioning plant for the dining saloon.

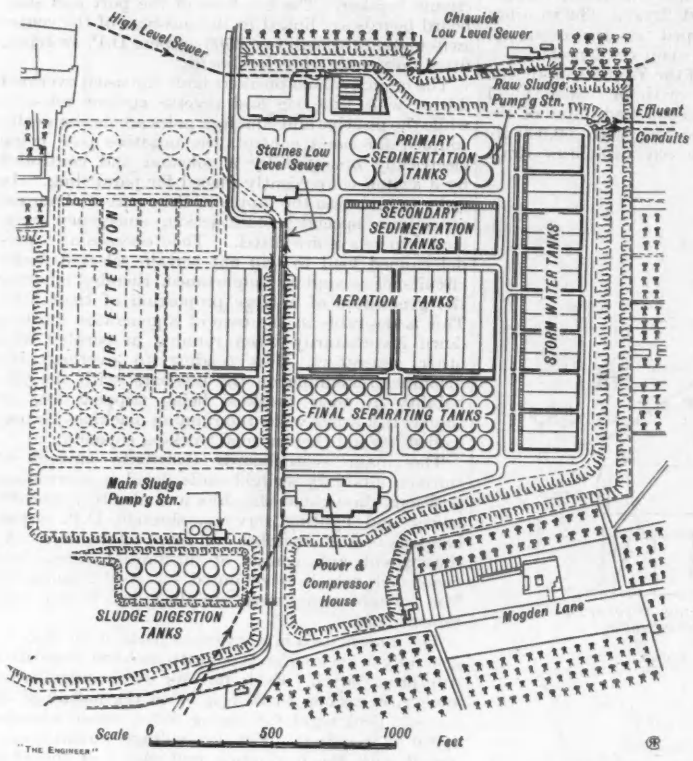
The refrigerating machinery, supplied and fitted by J. and E. Hall, Ltd., is arranged in a room on the tank top, forward of the boiler-room. It comprises four of the firm's latest type of electrically driven horizontal twin compressor machines. Under normal conditions two of the machines will deal with the insulated cargo and provision room duty, and one with the air conditioning, the fourth machine being a standby for either duty. Each machine has a pair of CO_2 compressors driven by a variable-speed electric motor of 125 b.h.p., coupled directly to the crankshaft. All of the working parts are enclosed and forced lubrication is fitted to all the principal bearing surfaces. There are four sets of CO_2 condenser coils of copper tube, each in a circular cast iron casing, and four sets of evaporator coils of steel tube in circular steel casings, arranged in an insulated room. For sea water circulation through the condensers there are two centrifugal pumps and for brine circulation there are five centrifugal pumps. The brine arrangements have been designed for the simultaneous circulation of brine at several different temperatures, as required for the various duties. The insulated cargo spaces are arranged for the carriage of frozen meat, butter, fruit, and chilled beef; suitable air coolers and fans being fitted where required for the carriage of fruit. In addition to the main CO_2 plant, a large number of "Hallmark" methyl chloride automatic machines have been fitted for dealing with cold cupboards in numerous bars, pantries, &c., in parts of the ship at some distance from the main plant, also for making and storage of ice cream. The whole of the equipment was supplied by J. and E. Hall, Ltd., and fitted up by the firm on board the ship at Barrow. The firm also supplied and fitted several electric lifts for passenger and cargo service.



HALF-SECTIONS THROUGH BOILER-ROOM

The West Middlesex Sewerage Scheme.

IN June, 1931, the Royal Assent was given to a Bill brought forward by the Middlesex County Council for the construction of a system of intercepting sewers to carry the sewage from a very large area in West Middlesex to a central purification works at Mogden. The scheme qualified for financial assistance from the Government, which, however, made it a condition that the work should be started before the end of October of the same year and completed by October 1st, 1935. At the time of writing, therefore, the major part of the work has been completed. The general features of this, the West Middlesex Sewerage Scheme, will be familiar to readers of our issue of March 17th, 1933, in which the general planning of the sewers was described and the work carried out up to that date illustrated. The scheme was called into being by the rapid development of an area of some 160 square miles, lying in the county of Middlesex, west of the watershed line passing through Finchley and Chipping Barnet. This area had, according to the census returns of 1921, a population of 493,120. By 1931 this figure had risen to 771,263, and the twenty-eight separate sewage disposal works existing at that date were hard put to it to deal with the needs of the increasing population. At the present time it is estimated that there are close on 1,000,000 inhabitants, and it is thought that the ultimate population is likely to reach 2,000,000. At the time that the Bill authorising the construction of the works was before Parliament, it was intended to build purification works suitable for an estimated population of about 750,000, but the rate of increase became more pronounced as from about 1929, and since the original estimates were framed it has been necessary to make provision at the purification works for a population of 1,250,000. Naturally sufficient ground has been obtained to allow for further extension of the works to meet the demands of the estimated ultimate population. Altogether, the scheme when developed as it will be in the near future to meet the needs of a population of 1,250,000, will have cost nearly £7,000,000.



PLAN OF MOGDEN PURIFICATION WORKS

In the direction of the design and construction of the works, the West Middlesex Drainage Committee, together with the consulting engineers, Messrs. J. D. and D. M. Watson, of Westminster, to whom we are indebted for information on which this article is based, have made it a rule that all works, such as main intercepting sewers, the effluent outlets to the Thames, and various buildings at the purification works shall be constructed of sufficient size to meet the demands of the ultimate estimated population. Only those parts which can in the future be easily extended without undue disturbance of works already carried out, such, for instance, as the purification works at Mogden, are being built to suit the needs of the smaller population of 1,250,000 souls likely to be inhabiting the area by 1940.

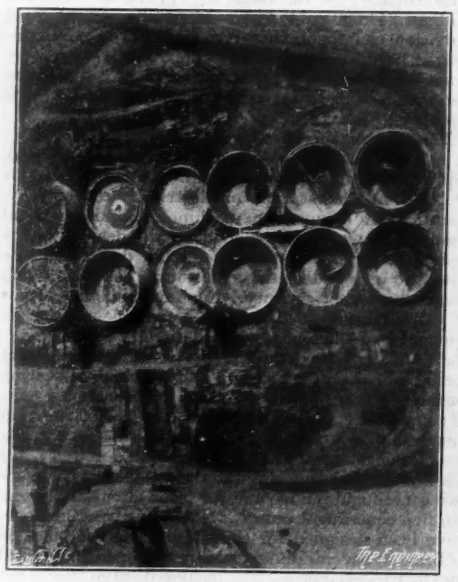
INTERCEPTING SEWERS.

The general plan of the works was discussed in our previous article in March, 1933, and we need not therefore do more than summarise what was said on that occasion. High-level sewers draining by gravitation serve the whole of the northern part of the area, comprising about 75 per cent. of the total. In the south, however, around Staines, Sunbury, and Hampton Wick, the ground is low-lying, and a system of low-level sewers has been constructed, draining by gravitation to a pump well at Mogden whence the sewage is lifted 50ft. to be discharged into the plant at the level of the high-level sewers.

The total length of main intercepting sewers amounts to about 67 miles of diameters ranging from 21in. to 12ft. 9in. An example of a 10ft. diameter sewer is illustrated on page 322. About one-third of the total length was constructed in open trench, and the remainder in tunnel. Naturally, with so great a variety of diameters and appreciable differences in the quality of the ground traversed, a number of differing constructions were adopted. For sewers up to about 4ft. in diameter cast iron or aluminous cement concrete pipes have been used. The larger sewers built in open trench have for the most part been built of reinforced concrete, and lined with brickwork. In tunnel they consist of two, three or four ring brickwork, cast iron segments lined with brickwork or concrete segments lined with brickwork, according to the nature of the ground. For the most part, owing to careful planning, the sewers have been driven through good London blue clay, but more difficult conditions were encountered in some neighbourhoods, and in a few instances work had to be carried out under compressed air. Shields have been used to quite a large extent, and were found advantageous even in good ground for the construction of the very largest sewers. For working in water-laden ballast without compressed air, a new type of shield, known as the Hunt-Kearney, was devised. Statutory obligations have made it necessary to gauge all flows discharging into the main sewerage system, and permanent flumes have been installed at all the larger connections. Although the system is not intended for storm relief, yet, until the population approaches 2,000,000, there will be a considerable spare capacity. Use is therefore to be made of the system for the relief of flooding up to its capacity. In the Brent valley syphon spillways have been constructed for the purpose of taking flood waters into the sewer from the river—an interesting application of a device which has not been much used in this country until lately. Among other interesting works in connection with the construction of the sewers, it may be noted that five inverted syphons were constructed, the largest of which passes under the river Brent, and is designed to carry 325 cusecs through six separate conduits, the inlets to which are set at different levels. The total discharging capacity of the sewers is about 575 million gallons per day.

The arrangements for the discharge of the effluent from the Mogden works are also of considerable interest. The effluent is discharged into twin culverts, each 11ft. in diameter, which are driven to the Thames at a depth of 50ft. under Isleworth. In the Isleworth Ait four penstock control chambers have been sunk and from each of these shafts three 6ft. diameter outlets lead under the main river channel, terminating in vertical outlet shafts built in steel caissons sunk in the river bed. The arrangement is such that the effluent will be diffused into the main stream of the river over a length of about 400 yards.

The 6ft. outlets are controlled by the valves made by Ham, Baker and Co., Ltd., of Langley Green, Birmingham, and shown in one of the illustrations. Operation of these valves is effected through heavy machine-cut gearing enclosed in cast iron split casings mounted on cast iron pillars. The operating hand wheel, by the use of which one man can raise the door through its maximum travel in fifteen minutes, rotates, through the gearing, a non-rising screwed gun-metal box about a rising spindle connected to the door. Any deposit that may accumulate around the lower part of the door can be discharged through a scour valve of the inverted cone type equipped with a separate headstock. Several of these valves were placed in position some months ago and have been subjected during the intervening time to the full tidal head of about 45ft. According to the makers,



SLUDGE DIGESTION TANKS UNDER CONSTRUCTION

AERIAL VIEW OF MOGDEN PURIFICATION WORKS

there has been no sign of leakage whatever during that time.

THE PURIFICATION WORKS.

A total area of about 150 acres has been acquired at Mogden, Isleworth, to accommodate the purification works. This area is more than adequate to meet present and future requirements, and there is sufficient space for the building up of embankments around the site formed by the tipping of spoil from excavations. According to present estimates, in fact, the plant required to meet the needs of an ultimate population of 2 million will only take up about 70 acres. Of this area 45 acres are being utilised at present. In accordance with the terms under which the Government agreed to make a grant towards the cost of carrying out the scheme, the work is now approaching completion, although we understand that it will still be some time before it comes into full operation owing to the need for the various adjustments arising from the taking over of the duties of twenty-seven other sewage disposal works.

Purification is to be effected principally by the activated sludge process, which gives as one of its advantages a great economy of space. The plant is designed to be of such capacity that volumes of sewage up to three times the dry weather flow will receive complete treatment, while partial treatment by sedimentation in storm water tanks will be given to any excess above that rate. It is estimated that the dry weather flow when the works first come into operation will be about 40 million gallons per day, which will increase eventually to 80 million gallons per day—a rate equal to 40 gallons per day per head of population. No storm water relief weir discharging directly into the river will be provided. Only sufficient plant is being constructed at present to meet the immediate demand, and the works will be extended as and when necessary in the future. Certain structures, however, which are hardly amenable to later extension, such as the main pumping station, the compressor house, and the administration buildings, for instance, have been designed in accordance with the ultimate requirements. Some idea of the work involved and the efficient organisation necessary to get it completed within the time available is given by the facts that nearly 2 million cubic yards of material have been excavated and 225,000 cubic yards of concrete placed; that a local river has been diverted for half-a-mile of its course; and that several miles of new roads have been constructed. All that work has been additional to the demolition of the sewage works which originally existed on the site. As was mentioned in our first article on the scheme, the material found on the site consisted of a layer of sand and gravel of an average depth of 15ft. overlying a solid bed of blue clay, which provided excellent foundations. Peak outputs of as much as 1000 cubic yards of concrete placed and 8000 cubic yards of material excavated per day have been recorded.

There is nothing of a particularly unusual nature about the plant or the methods to be used for the purification of the sewage. As in many other works built since the war, the activated sludge process, which has been described before in THE ENGINEER, is to be used. On entering the works the sewage from high and low-level sewers first passes through a screening and grit removal plant divided into six independent units, each capable of dealing with 95 million gallons per day. These units are so arranged as to be brought into use successively as the flow increases by automatic hydraulically controlled penstocks. The total capacity of all six units is in excess of the maximum discharge of 575 million gallons per day for which the sewerage system has been designed. Measurement of the flow is carried out at the outlet from each grit chamber by a standing wave Venturi flume. Any flow above three times the ordinary dry weather flow will thereafter be diverted into storm water tanks—see the plan, page 328—of which there are eight, each 230ft. long by 150ft. wide by 12ft. deep and having a total capacity of 20,000,000 gallons. Electrically operated Mieder type scrapers will move sludge deposited on the floors to hoppers at the ends of the tanks, whence it will be discharged into the sludge main. One scraper will serve a number of tanks and the blade which performs the task will be available when travelling in the reverse direction for the removal of scum. Sewage undergoing full treatment passes from the grit chambers into primary and secondary sedimentation tanks having total capacities of 4,500,000 gallons and 9,000,000 gallons respectively, from which sludge is removed to the sludge main. The eight primary tanks are 95ft. in diameter by 12ft. deep and the four secondary tanks are rectangular, 200ft. by 150ft. by 12ft. deep. After this preliminary treatment, which is rendered the more effective by the fact that excess activated sludge from the aeration tanks is pumped back into the raw sewage before it enters the sedimentation tanks, the sewage will pass on to the activated sludge process tanks. This part of the plant consists of two batteries of six units each, and the gross capacity is 20,000,000 gallons. Each unit has four channels, 400ft. long by 15ft. wide by 12ft. deep. In the design of these aeration tanks arrangements have been made for a comparison of the merits of the "spiral flow" and "longitudinal ridge and furrow" principles, and should either system prove markedly superior the battery not so constructed will be converted. Settling tanks with a total capacity of 10,000,000 gallons and a maximum rate of upward flow of 7·5ft. per hour follow the aeration tanks. Any proportion of activated sludge from these tanks between 15 and 50 per cent. of the dry weather flow can be returned into the incoming sewage with an additional maximum of 50 per cent. of the final clarified effluent as well if that is found desirable. Up to four units are so designed as to be capable of use for sludge reconditioning. The surplus sludge, as already noted, is pumped into the flow of raw sewage before it enters the sedimentation tanks.

In addition to the plant described, the construction of three more aeration tanks and associated plant has been begun in accordance with the fact that the rate of increase of the population has been greater than was provided for under the original parliamentary proposals.

SLUDGE DIGESTION AND DISPOSAL.

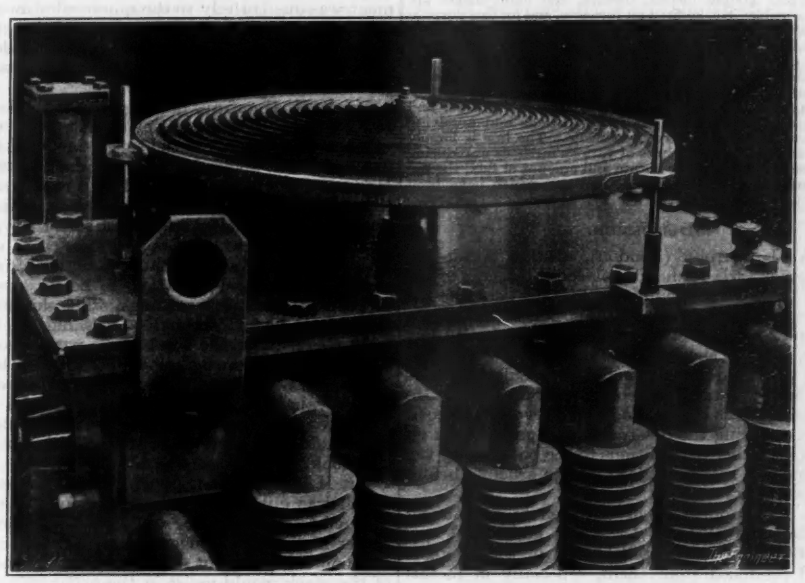
Crude sludge obtained from the primary and secondary sedimentation tanks and the storm water tanks is to be pumped to the south of the site and delivered into two thickening tanks, 35ft. diameter by 20ft. side water depth before going to a bank of sludge digestion tanks. This latter plant, which is illustrated under construction on page 328, consists of twelve tanks, 70ft. in diameter, having a total capacity of 10,000,000 gallons. Eight tanks will be provided with gasholders of a total capacity of 250,000 cubic feet, and the remainder are to have fixed roofs. In accordance with the usual arrangement under this system, the methane gas produced will be used for the generation of power in the power-house and compressor house, while the waste heat from the gas engines will be utilised to maintain the temperature of the digesting sludge at about 80 deg. Fah. Power from the methane gas will be generated in ten convertible oil engines, each giving 550 b.h.p. when using gas as a fuel. Six of the engines will drive compressors, each capable of delivering 12,500 cubic feet of free air per minute against a pressure of 7 lb. per square inch for the supply of the aeration tanks, and the remainder will supply D.C. current at 460 volts for the running of pumping plant and other auxiliary machinery and for lighting.

On leaving the digestion tanks the sludge is to be pumped 7 miles to a site at Perry Oaks of about 240 acres. The pumping main consists of two 12in. cast iron pipes, which for about one-half of the distance are slung from the soffit of the arch of one of the intercepting sewers and for the remainder are laid in open trench. At Perry Oaks the sludge is to undergo a further stage of digestion in ten tanks, 100ft. diameter with a total capacity of 15,000,000 gallons, before being laid upon drying beds covering an area of about 50 acres. These beds are formed of sand and gravel obtained from the site, the total thickness of the drying medium being 18in., graded from coarse gravel at the bottom to fine sand at the top. The whole area has a system of under-drainage to one of the main intercepting sewers and is surrounded by a wall of puddle clay carried down from the surface to the underlying strata of London clay. The object of this impervious wall, of course, is to prevent any risk of the contamination of the subsoil water in the surrounding gravel.

EXPERIMENTAL television broadcasts have been carried on for some time in France, and it is announced that the Minister of Posts and Telegraphs intends to set up a special transmitter of 10 kW at the top of the Eiffel Tower. Good results are expected in Paris from the new transmitter, which will broadcast on a wavelength of 7 m. on a 180-line screen.

Hermetically Sealed Transformers.

WHEN transformers are operated in damp or dirty situations the oil is liable to contamination. Breathers of the ordinary kind will absorb moisture from the air produced as the transformer cools, but they require regular attention and afford no protection against storm water, when transformers are installed in pits liable to be flooded. Hermetically sealed transformers made by the British Electric Transformer Company, Ltd., of Hayes, Middlesex, overcome the trouble and expense of maintaining breathers and are designed to afford complete protection against damp or even flooding. The advantages claimed for them are (1) no contact between the oil and atmosphere; (2) no breathing; (3) no waste of oil; and (4) no maintenance.



HERMETICALLY SEALED TRANSFORMER WITH COVER REMOVED

Provision for expansion and contraction of the oil owing to temperature variations and heating of the transformer on load is made by an expansion chamber attached at its centre to the tank lid, so that the interior of the chamber is in communication with the parent tank. The expansion chamber, which is usually filled with oil, has flexible sides, which are free to bulge outwards or buckle inwards, and thus allow for expansion and contraction of the oil. A special construction has been adopted to guard against the effects of fatigue of the metal by the repeated movement. A light steel cover encloses the oil chamber, which is suitable for all transformers, of small and medium size. To ensure that the correct amount of oil is used, the final filling is done while the transformer is hot, a procedure which is necessary to ensure that the expansion chamber is not overstrained when the transformer reaches its maximum temperature. The accompanying illustration shows a transformer with the sheet steel cover removed to expose the oil container.

SIXTY YEARS AGO.

SEPTEMBER 27TH 1875 marked the fiftieth anniversary of the opening of the Stockton and Darlington Railway for passenger traffic. The occasion was celebrated with fitting honour. At the invitation of the directors of the North-Eastern Railway a large concourse of engineers and others assembled at Darlington. The first item in the proceedings consisted of a march of directors, mayors, corporations, and temperance and friendly societies accompanied by a dozen bands. The procession assembled in the market square and proceeded to the North Road Engine Works where an exhibition of locomotives was opened. There were about twenty-four engines on show including the "Locomotion," which after twenty-five years' service following its historic trip on the opening day had been retired and carefully preserved. Subsequently the procession returned to the market square where a statue, heroic in size, of the late Mr. Joseph Pease was unveiled. In the evening a banquet "one of the most splendid and extensive that has ever taken place in the North of England" was held in a marquee erected on the local cricket ground. In our issue of September 24th 1875 we discussed in a leading article some of the difficulties and triumphs of the early locomotive builders. It was not easy, we said, for engineers of the present generation to form a just conception of the difficulties encountered and overcome by men such as George Stephenson and Trevithick. To build a locomotive without any tools but hammers and chisels, a few drills and a poor lathe worked by men or horses and with no labour more skilled or experienced than that afforded by a couple of dozen village blacksmiths was a task which the modern locomotive superintendent would give up in despair. Yet Stephenson actually accomplished it. Were there, we asked, at that moment half a dozen engineers alive who under such conditions could have built the "Locomotion"? Our early locomotives were not relics of barbarism; they were infinitely more remarkable as examples of the power of mind over matter than the finest modern engines. As evidences of the possession of indomitable pluck, splendid mechanical genius and all-conquering energy they were unequalled. It was a good thing to honour the memory of those now dead who while in life wrought such deeds.

Institute of Metals.

No. III.

(*Continued from page 289, September 20th.*)

ON Tuesday morning, September 10th, a paper entitled "Metal Losses in Melting Brass and other Copper Alloys," by Dr. Maurice Cook, was presented for discussion. A summary of the contents follows.

METAL LOSSES IN MELTING COPPER ALLOYS.

A study has been made of the metal losses which occur when such alloys as gilding metals, brasses, and cupro-nickel are melted in crucibles in coke-fired pit furnaces, and for this purpose figures have been obtained, both from carefully controlled trials and from production runs, involving the melting of considerable quantities of material under different conditions. Observations have also been made on the metal losses occurring in melting brasses of different compositions under various conditions of fluxing in Ajax-Wyatt induction furnaces, and large-scale trials covering considerable periods and involving large tonnages of metal have been made. The loss is largely due to oxidation and the results of various methods of reducing the loss, such as varying the nature and amount of flux, the use of charcoal, coke, anthracite, and coal gas, which have been tried, are discussed.

DISCUSSION.

Mr. A. J. Murphy (London), after a tribute to I.C.I. Metals, Ltd., for having placed the results of the working of several plants at the disposal of the Institute, asked what was the function of the salt in the complex mixture of charcoal, borax and salt. For instance, was it shown quite definitely that when working with charcoal and borax the results were not so good as when using charcoal, borax and salt? He also asked whether Dr. Cook had evolved special means of reducing the destructive action of borax on refractories, either by additions to the borax or by the formation of a resistant glaze on the crucible before using the borax.

As to the application of coal gas to a reducing atmosphere, he asked if Dr. Cook had noted any effect of gassing in the billets and in the wrought material produced from them, especially in metals other than brass. Further, was there any merit in using coal gas solely in the melting stage?

Mr. W. F. Brazener (Birmingham) gave some records of metal losses in crucible melting, showing that, on the basis of an ingot requiring a final copper figure of 62 per cent., for virgin metal mixtures the copper charged should be 61½ per cent.; for mixtures with 40 per cent. of ordinary process scrap the copper charged should be 61 per cent.; and for mixtures with about 50 per cent. of light and dirty scrap the charging figure should be 60½ per cent. Those results were approximately identical with the stack loss figures indicated in the paper. Commenting on the author's cautionary note concerning the rich copper alloys of the 97/3 variety, he said that where close limits of composition were to be maintained it was essential, in view of the very small loss which occurred, that the weighing of the charges should be very accurate; any slight overweight in the zinc put into the crucible would be evident in the final analysis of the ingot. Failure to watch that matter had caused considerable trouble and anxiety. In crucible melting with a normal charge containing a certain percentage of process scrap, it was customary for the caster to charge the crucible first with a convenient bundle of brass scrap and then to stack the ingot copper on top; the main idea was that the brass bundle acted as a cushion for the copper and, as the brass melted, the copper gradually sank to the bottom of the crucible. Although from the point of view of convenience, and probably the ultimate speed of melting, that method had some slight advantages, there was certain disadvantage in the extra loss sustained due to the zinc volatilisation.

Commenting on a figure of 0·22 per cent. representing the metal in ashes in the case of the 64/36 brass ingots, Mr. Brazener pointed out that that was the actual loss of metal charged into the crucible, and it should not be confused with the metal content of the ashes ultimately raked out from under the furnaces. As a general rule the metal content of caster's ashes was between 5 and 8 per cent.

Confirming the author's reference to losses occurring in the process of manufacture of the ingot, owing to annealings and picklings, he said he had been mystified in the past by the fact that fine wire was found to contain about ½ per cent. more copper than the ingot from which it was made. That might mean quite a big difference in the fabricating properties of certain qualities of wire.

Professor R. S. Hutton (Cambridge) said it would have been very interesting to know how the losses recorded in the paper compared with those experienced by the author's predecessors in the days when open-hearth furnaces of rather crude type were used for making yellow metal. Presumably the losses then were very much higher than in the modern pit furnaces or Ajax-Wyatt furnaces. The figures in the paper representing total overall loss when using the Ajax-Wyatt furnace did not show a very great advance on the best crucible melting practice, a fact which was very stimulating because it seemed to indicate that a good deal more could be done; the Ajax-Wyatt principles were very much nearer the ideal than those of the pit furnace, and one would anticipate very much better results with the former when further studies such as those of Dr. Cook were completed.

Recalling an experience in the melting of nickel-silver filings, he said that when crucible furnaces were used the final ingot contained about 25 per cent. of the gross weight of the filings; but in an arc furnace about 85 per cent. was recovered. He believed the improvement was due entirely to the quiescent atmosphere in the furnace; the melting was carried out in the atmosphere of zinc vapour, which was condensed on the cooler parts of the furnace and was largely recovered and retained.

Mr. S. G. Homfray, dealing with crucible melting results, said that Dr. Cook's statement that the amount of metal lost in the ashes should be less than 0·25 per cent. showed a high standard of efficiency. He gave some figures obtained on furnaces similar to those referred to by Dr. Cook, though they were operated on a smaller scale, and said the yield over the last four years had been 96·67 per cent., on a very miscellaneous production and using materials of all kinds—some virgin metal, some heavy scrap, some light scrap, and a few turnings. The skimmings and ashes were passed through a washing machine and 2·12 per cent. of the total issues were recovered in that way, the figure corresponding to stack loss being 1·21 per cent. That figure would be reduced slightly if the value of the ash residue from the washing machines were taken into account. The figures, on the whole, appeared to confirm those obtained by Dr. Cook.

Mr. H. N. Bassett (Egypt), referring to stack loss, which was given as 1 per cent. in one of the trials referred to in the paper, said that that figure seemed rather high, and he suggested that determination of the zinc oxide content of the flue dust at the bottom of the stack would assist in the accurate assessment of the stack loss. He was disappointed that the paper did not give more help in regard to crucible melting. In a foundry in Egypt he was melting about 400 tons a year of bronze of various qualities, a considerable amount in pit fires and the remainder in oil-fired tilting furnaces. He was looking for something which could be operated by native workers who were not too quick in the uptake.

In view of the serious attack of a borax flux upon crucibles, he asked if Dr. Cook had discovered a proprietary refractory which would withstand that erosive action, or, if not, whether he could suggest a means of overcoming it.

Mr. F. Hargreaves (Eastleigh) asked what accuracy Dr. Cook could achieve in determining losses by taking weighings in and weighings out, because in many conditions such procedure was not possible; one was more or less reduced to weighing skimmings and examining them. Skimmings consisted mainly of metallics and oxides of heavy metals. In the oil-fired reverberatory furnace the lining was not attacked very much, but built up. It seemed that in such cases, if one could make the flux or skimmings sufficiently fluid at the temperature of working, the metallics should sink, and that under ideal conditions there should be no metal losses as such. Secondly, as the lining was not attacked very much, there seemed no reason why the oxides of the metal should not be reduced, by means of charcoal or some other reducing agent. If those two things could be accomplished the losses should be almost negligible.

Mr. A. G. Robiette (Birmingham) said that the economic importance of reducing loss to a minimum had been emphasised, but the value of obtaining a fairly consistent loss should be stressed also; erratic results were most disconcerting from the point of view of alteration in composition, making it difficult to compensate for the loss.

Discussing the influence of the age of the refractory upon metal losses, he said that in certain cases an abnormal loss was recorded up to about the first ten heats. In the first four or five heats the metal loss might be 4 or 5 per cent. above the normal, accounted for solely by the absorption of metal, especially lead and zinc, in the pores of the refractory. He assumed that in Dr. Cook's investigations the linings used had already "seasoned." It was unfortunate that the investigation did not extend to the rocking arc furnace and the reverberatory, both of which were used widely for the melting of copper-rich alloys; comparisons could then have been made between the respective types of plant.

The work described in the paper admittedly referred to strip and billet casting practice, and the figures could not be regarded as representing foundry practice. In the latter, casting temperatures were usually consistently higher, whilst metal losses, especially by volatilisation, increased very markedly with rise of temperature. In many cases pouring temperatures approached the temperature of free volatilisation of the alloy—*i.e.*, its boiling point. Moreover, the method of computation of loss was usually different in the foundry, and was affected on the basis of the weight of the charge, and the weight of metal subsequently in the ladle or shanks. That eliminated the loss by spillings and splashings, and he regarded it as a fairer method of calculation.

Dr. A. G. Ramsay (Swansea) said he had used anthracite as a cover for Ajax-Wyatt brass melting for several years, with really remarkable results. It was in the form of rather fine powder, and was thrown on to the molten bath where it acted as an almost perfect blanket, and it afforded a reducing atmosphere. A great advantage was that its price at pithead was only about 7s. 6d. per ton, as compared with about £5 per ton for charcoal.

Mr. Colin Gresty (Wallsend-on-Tyne), replying to Mr. Bassett's request for figures of metal loss in foundries dealing with Admiralty gun-metal and lower-grade gun-metals, said that during the last six years at his works the loss on that class of work had been 2·23 per cent. It was interesting that during the first two years of that period, when the output of the foundry was rather high, the loss was 2·72 per. cent., whereas during the slump of the last four years the loss had been reduced to 1·42 per cent. In another foundry which was partly under his control the records of the last two years showed a loss of 1·7 per cent., the foundry again working below capacity.

Dr. Cook, replying to Mr. Murphy, said he was not quite sure what was the function of salt when mixed with borax, but the results obtained with that mixture, added at the stage of operation indicated in the paper, were definitely better than when borax alone was added. As to the effect of coal gas in reducing the amount of oxidation occurring, he said it was true that the effect occurred almost exclusively during the melting period. Unquestionably, that was the time at which most oxidation and dross formation occurred. He had not experimented in connection with the attack of such fluxes as borax upon refractories used in Ajax-Wyatt furnaces and crucibles, but in view of its importance it was a matter to which attention might profitably be directed.

A paper entitled "Observations of the Porosity and Segregation of Two Bronze Ingots," by Dr. N. P. Allen and Mr. S. M. Puddephat, was then presented and discussed.

The distribution of porosity and the variation in copper content in two 10 per cent. tin-bronze ingots have been found by the authors to be influenced principally by the flow of heat during solidification. A close connection between the porosity and segregation of the ingots was found.

Finally a paper on "The Properties of some Special Bronzes," by Professor Hanson and Mr. M. A. Wheeler, which is summarised below, was presented by Professor Hanson, but there was no time for discussion.

SOME SPECIAL BRONZES.

Additions of aluminium, manganese, aluminium plus manganese, iron and silicon, have been made to copper-tin bronzes.

(1) *Aluminium.*—Within the range of compositions investigated alloys consisting of one solid solution work readily, hot or cold. Alloys possessing a duplex structure can be worked with much greater difficulty, and are specially difficult in hot working. The range of compositions in which easy working properties can be obtained can be extended by annealing duplex alloys to give a homogeneous structure. Annealed alloys possess very good ductility; the maximum tensile strength attained in annealed alloys was 30 tons per square inch in an alloy containing 4 per cent. aluminium and 5 per cent. tin. Alloys containing 2 per cent. or more aluminium are fairly resistant to oxidation at high temperatures, particularly if the cast surface is not damaged. Polished alloys have a pleasing appearance, and are fairly resistant to tarnishing in the air. The scale formed when the alloys are heated is very difficult to remove, either mechanically or by pickling processes.

(2) *Manganese.*—Manganese has a relatively small influence on the working properties of a 5 per cent. tin bronze. As much as 6 per cent. of manganese must be added before an appreciable embrittling effect is apparent. Alloys within the range of composition investigated can be worked hot or cold.

Manganese increases the softening temperature of the tin bronzes.

(3) *Aluminium and Manganese.*—Copper-tin bronzes containing aluminium and manganese, within the range investigated, are difficult to cold work, without annealing, if the aluminium content exceeds about 0·25 per cent. With aluminium contents up to about 3 per cent., they may be cold worked if they are previously rendered homogeneous in structure by annealing. Aluminium increases the tensile strength of manganese-tin bronzes, without appreciably reducing the ductility.

(4) *Iron.*—Iron, in the form of American washed iron, alloys readily with copper, and 4 per cent. of iron can be incorporated without difficulty. No trouble was experienced in obtaining good castings. Iron-tin-copper alloys containing 5 per cent. of tin and up to 4 per cent. of iron, can be rolled, and the ductility decreases only slightly even when 3 or 4 per cent. of iron is present. Iron up to 1·5 per cent. has little effect on the tensile properties of a 5 per cent. tin bronze, but 2 per cent. or more of iron increases the tensile strength at the expense of the ductility. The iron is distributed uniformly throughout the solid alloy in the form of small particles, the structures being very similar to those of iron-copper alloys containing no tin; 4 per cent. of iron greatly refines the cast structure of a 5 per cent. tin bronze.

(5) *Silicon.*—Silicon has a marked effect on the cold-working properties of a 5 per cent. tin bronze. An alloy containing 3 per cent. of silicon can be cold worked only with great difficulty in the "as cast" condition; after annealing at 800 deg. Cent. for four hours the cold-working properties are slightly increased. The addition of 4 per cent. of silicon to a 5 per cent. tin bronze renders the material unworkable, both hot and cold. The addition of silicon greatly increases the strength of a tin bronze.

ON Wednesday morning, a paper on "The Interrelation of Age Hardening and Creep Performance: Part I, The Age Hardening of Nickel-Silicon-Copper Alloys," by Dr. C. H. M. Jenkins and Mr. E. H. Bucknall, with an appendix on "The Relationship of Time, Temperature, and Concentration as Factors

in Age Hardening," was discussed. The authors' summary runs as follows.

AGE HARDENING OF NICKEL-SILICON COPPER ALLOYS.

A report is given of an investigation on the age hardening of nickel-silicon-copper alloys containing 3 and 5 per cent. nickel + silicon in the atomic ratio 2 Ni : 1 Si. This work, which was carried out as a preliminary to the study of the inter-relation of the age hardening of this material and its creep performance, has provided sufficient information to serve as a basis for the creep test programme and to assist in the interpretation of the creep results.

The alloy containing 3 per cent. nickel + silicon, when quenched from 900 deg. Cent., undergoes age hardening at temperatures of 300–750 deg. Cent. The maximum hardness is attained progressively more rapidly the higher the ageing temperature, being reached, for example, in more than sixty-four days at 400 deg. Cent. and in less than one minute at 700 deg. Cent. In general, a linear relationship appears to apply between the logarithm of the time and the reciprocal of the absolute temperature of attainment of maximum hardness. The maximum hardness is greater the lower the ageing temperature. The attainment of maximum hardness is generally followed by softening.

Microscopical and chemical evidence of the progress of ageing has been obtained, but X-ray study has not been of great assistance in this instance.

In the Appendix consideration is given to points relating to the age hardening of nickel-silicon-copper alloys and their comparison with information in the literature relating to other age-hardenable alloys. Particular attention is directed to the importance of the relationship between temperature and time of attainment of maximum hardness, which is shown to be of general application. A similar relationship applies to the attainment of maximum resistivity during ageing. These relationships are regarded as confirming the commonly accepted theory of age hardening.

DISCUSSION.

Dr. Maurice Cook said that he had a very keen sense of disappointment after reading the paper, for he had expected a connection to be drawn between age hardening and creep, but creep was hardly referred to. However, the paper was the first of a series, and he hoped the authors would see to it that in any further paper the subject matter and title were not so far removed from each other as in this case. In regard to physical properties, all that the paper contained was a series of hardness curves, and these had been masquerading under a grandiose and misleading title!

The temperature to which these age-hardening alloys were heated, and the period during which they were maintained at that temperature, was very important in connection with the subsequent hardness. In the paper he could see reference to only one temperature used by the authors, *i.e.*, 900 deg. Cent., and in view of the references, in the portion of the paper dealing with "Experimental Investigation," to the very variable hardness results, he was wondering whether, if the authors had used a higher temperature, they might have obtained more consistent results in the soft state. He had had experience of copper-nickel-silicon with a total nickel + silicon content of about 1¼ per cent., and had not experienced any difficulty whatever in obtaining a fully softened condition on quenching. That confirmed the authors' observation that when the nickel + silicon content was reduced from 5 to 2 per cent. it was easy to maintain the alloy in the soft condition. He had noticed that iron or manganese was not necessary in order to obtain full softening, but the presence of very small amounts of iron did accelerate the ageing process and appeared to increase the extent to which the hardening could be obtained. In view of the possibly very great importance of small quantities of impurities, it was a pity that the authors had not given complete analyses of the alloys.

Dr. Hugh O'Neill congratulated the authors on having deduced a general law relating the time and temperature required to bring about maximum age hardening in alloys. Physical metallurgy would make rapid progress with the aid of these laws or relationships, because it would be possible to forecast what could be done. The authors had observed that their exponential ageing relation was similar to the law of Dushman and Langmuir applying to diffusion in the solid state. Bailey and Roberts ("Proc.," Inst. Mech. Eng., 1932, I, 209) had obtained the same type of expression for the process of spheroidisation of steel. In the discussion on that paper, Dr. O'Neill had suggested that the age-hardening process might be considered on the basis of Bailey and Roberts' work, and that had been done by Dr. Jenkins and Mr. Bucknall with considerable success. The evidence brought forward in the present paper showed that over at least an extensive range of hardening (and apart from any possible hardness fluctuations), the authors' expressions held good. At the same time, there were examples which tended to show that the law applied only over a definite range.

With regard to the authors' statement that the maximum tensile strength and the maximum electrical resistivity were not necessarily produced by the treatment which gave the maximum hardness value, Dr. O'Neill did not think that that was as certain as the authors seemed to indicate. When referring to "hardness" the authors had meant the Brinell number for the arbitrary loading conditions of $L/D^2=10$. He asked if they were certain that if they had used other loading values, such as $L/D^2=5$, or 30, the hardness maximum for a given alloy and a given time would have occurred at the same ageing temperature. Brinell numbers were not scientifically comparable the one with the other, and whilst that was seldom important in ordinary work, it might lead to trouble when comparing Brinell hardness with more precise properties such as electrical resistivity. Having given some examples of how the position of a "hardness" maximum might vary with the method chosen for computing the ball hardness value, he suggested that it would be preferable to use the diamond pyramid test for work of that kind, for the hardness numerals thus obtained were truly comparable, though they had to be referred to the angle of the pyramid employed.

Dr. M. L. V. Gaylor, in a written contribution, raised the question, as the result of the examination of the microstructure of some of the alloys referred to in the paper, whether the changes occurring during the age hardening were due solely to the precipitation of a ternary phase, as the authors had suggested. Visible change in microstructure occurring during age hardening had been observed only in those alloys, such as copper-beryllium, zinc-aluminium, iron-carbon, &c., in which at least two factors were responsible for age hardening—(1) the suppression of a transformation, which occurred with time at room or higher temperatures, and (2) the decomposition of a supersaturated solid solution. Amongst simple binary systems, where the age hardening was due only to the separation of a second phase, no microstructural changes had been observed. It was unfortunate, therefore, that the constitution of the copper-nickel-silicon alloys was apparently unknown when their age hardening was being considered.

Dr. Gaylor made reference to a theory put forward previously by Mr. Preston and herself, that age hardening was due to the decomposition of the supersaturated solid solution occurring in two stages, and said that if it were sound, maximum hardness, as determined from hardness-time curves, had no very definite physical meaning; on the other hand, the maxima of electrical resistivity measured during age hardening had a very real meaning. Although the simplicity of taking hardness measurements might account for the use of the property of hardness as a means of indicating age hardening, physical properties such as electrical resistivity were more suitable for fundamental data.

Again, Dr. Gaylor was not quite satisfied with the straight-line relationship between times to attain maximum hardness plotted logarithmically against the reciprocal of absolute temperature of ageing, as put forward in the paper. Long-time ageing data were difficult to obtain, but until some were available the authors' relationship would not be proven. That criticism did not apply to the corresponding relationship with electrical resistivity, for in that case an entirely different physical condition was considered.

Professor D. Hanson, whilst interested in the theoretical part of the paper, suggested that it would have been more satisfactory if the work had been done on a system known to conform to the classical theory of age hardening, in which physical measurements and dilatation measurements, and so on, showed that precipitation did occur during age hardening. The authors had linked age hardening with a system the exact mechanism of which was not yet known. The view of the mechanism of age hardening as a precipitation process was quite consistent with the straight-line relationship. But Professor Hanson asserted that extrapolation in the case of duralumin was a particularly unfortunate instance, because in that case precipitation did not necessarily occur during room temperature hardening. There were other cases in which age hardening did not conform to the classical theory, and in the present state of our knowledge there was danger in applying in such cases generalisations based on systems which had a different mechanism.

Mr. W. T. Griffiths said, that having regard to the trend of the discussion, he felt it was right to begin publishing the results of the work; but he suggested that metallurgists were a very long way from obtaining proof of the theories put forward or even of being certain that they could draw deductions from the information available. The authors had dealt principally with alloys which admittedly were not the simplest, and he hoped that in the future they would be able to present data showing the effect of various other elements on the nickel-copper-silicon alloys. From a practical point of view, it was only in the ternary and more highly alloyed materials that alloys of practical value would be obtained; the nickel-copper alloys, as the authors had shown, were so simple and liable to harden so rapidly that one could not use them for examining creep or other essential properties at ordinary temperatures. It was unfortunate that views on phenomena of ageing were arrived at by talking about and measuring hardening. As suggested by Dr. Gaylor, measurements of other properties, such as resistivity, or even other mechanical properties, and under a variety of conditions, might give an entirely different picture. He hoped that, whilst the term "hardening" continued to be used, the authors would not confine their attention to measurements made by some indentation system.

Dr. W. J. P. Rohn (Germany), who emphasised the importance of the phenomena of ageing from the point of view of our knowledge of metallic qualities and properties, suggested that it would be useful to extend the researches to simple systems. Most of the research had been carried out on rather complicated systems, such as duralumin, in which there were two different kinds of age hardening at room and elevated temperatures; the systems investigated by the authors were of a somewhat more complicated type than the binary alloys. He suggested, for instance, experimenting with nickel-beryllium alloys, in which we had prototypes of ageing alloys.

Mr. Bucknall, replying to the discussion, said that so far as the authors were concerned, the investigation was a sideline of a sideline of a sideline, and the depth to which they could penetrate was somewhat limited; they appreciated the suggestions for further work, but the probability of carrying it out in the immediate future was not great.

He was not quite certain about Dr. Gaylor's suggestion that it was only in alloys where there was a suppressed transformation as well as solubility change that one could obtain microscopical evidence of precipitation; he had always understood that in the antimony-lead system, a straightforward solubility case, one obtained definite evidence of precipitation.

As to the disagreement of hardness curves taken under different loading conditions, he said that surely that would go further to establish the authors' point that the hardness maximum did not agree with the resistivity maximum, and that the maximum hardness stage merely represented a balance between two opposing factors so far as that particular test was concerned.

Finally, he assured Dr. Cook that Part II of the paper, which the authors hoped to present to the Institute before long, would contain a lot concerning creep. The work was already well advanced, but it was too early yet to deal with it in detail.

Dr. Jenkins, replying to the criticisms of Dr. Cook and Professor Hanson, said that work on age hardening had been proceeding for twenty years, and at least 10,000 man-years had been devoted to the study of age hardening as a theoretical basis. The authors had tried to interpret other work on a common basis; they had accepted what they had thought were the optimum conditions as published by previous workers in regard to copper-nickel-silicon, and the figures were not arbitrarily chosen. They did not think it necessary to reconsider factors such as maximum quenching temperatures; where they had found a divergence they had mentioned it in the paper.

(To be continued.)

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W.1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

IDENTIFICATION OF PIPES, &c., IN BUILDINGS.

No. 617—1935. This Specification for the Identification of Pipes, Conduits, Ducts, and Cables in Buildings was drawn up at the request of the Royal Institute of British Architects, and has been in course of preparation since 1932. The scheme adopted comprises a standard colour and a specially shaped identification plate for each service appropriately stamped with a distinguishing lettering to denote the classes of the service.

SIGNAL GLASSES AND LENSES FOR RAILWAY PURPOSES.

No. 623—1935 and No. 624—1935. Two specifications for railway purposes, one dealing with Colours for Signal Glasses, B.S.S. No. 623—1935, and the other with Plano-Convex (Bullseye) Lenses, B.S.S. No. 624—1935, have recently been issued. The figures in the first-named specification do not refer to the colour or brightness of the signal as seen by an observer, but to the colorimetric and photometric properties of the lenses or other glasses under specified conditions suitable for laboratory tests. The photometric property which is specified is transmittance and not transmission, the reason being that this property simplifies the procedure of testing by the usual substitution method. The quantity which emerges directly from this test, in which the coloured lens is substituted for a clear lens of the same size and shape, is the ratio of the transmissions of the coloured and clear lenses. By making a small correction for the absorption of the clear lens the transmittance of the coloured lens is obtained.

The second-named specification gives the diameter and focal distance of the lens and the thickness of the edge of the rim. It also specifies the colour and the method of measurement of the transmission.

PORTABLE PHOTOMETERS.

No. 230—1935. A revision of Specification No. 230 for Portable Photometers (Visual Type) has just been issued. It was undertaken chiefly at the request of the Street Lighting Committee of the Institution, which required a photometer with a greater degree of accuracy than that provided for in the original issue of the specification. The limits of error have therefore been reduced from 15 to 10 per cent., and the effective range of the photometer has been modified.

THREE of the 200ft. high wooden water cooling towers at the Lister Drive power station at Liverpool have been destroyed by fire.

Strength and Flexibility of Corrugated Piping.*

By ROBERT L. DENNISON.

No. II.

(*Continued from page 304, September 20th.*)

Material Under Investigation.

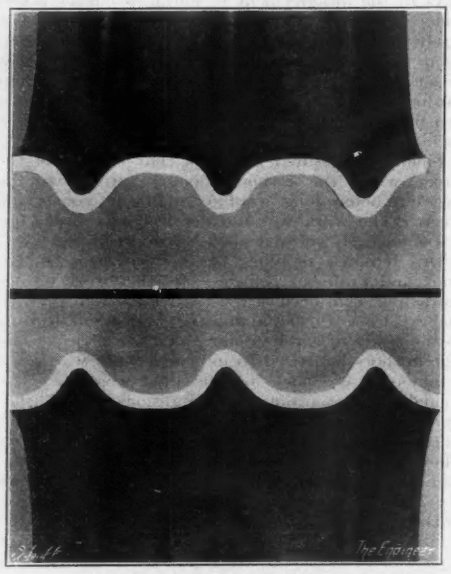
Classification of the Various Types of Piping.—This investigation covers three classes of pipe shapes, all constructed from 6in. seamless steel tubing, as follows:—

Series A: Corrugated piping with nominal wall thickness 0·280in. and shape of corrugation as shown on Fig. 1.

Series B: Corrugated piping with nominal wall thickness 0·288in. and shape of corrugation as shown on Fig. 2.

Series C: Creased bend piping of a typical shape of crease as shown in Fig. 3 and with nominal wall thickness 0·288in.

Complete tabulations of the pipe shapes investigated



Figs. 1 and 2—Profiles of Typical Corrugations in Series A and Series B Piping

under each of the above classifications, together with details of heat treatments and physical properties, are given in Tables I and II.

The Individuality of the Corrugation and Crease.—In manufacturing a corrugated pipe the seamless steel tubing is placed in a press between a fixed and movable head. A gas-fired ring furnace is placed around the pipe and a narrow band heated. When the pipe has reached a proper temperature, it is compressed along its axis by the press, thus raising a corrugation in the heated section. When

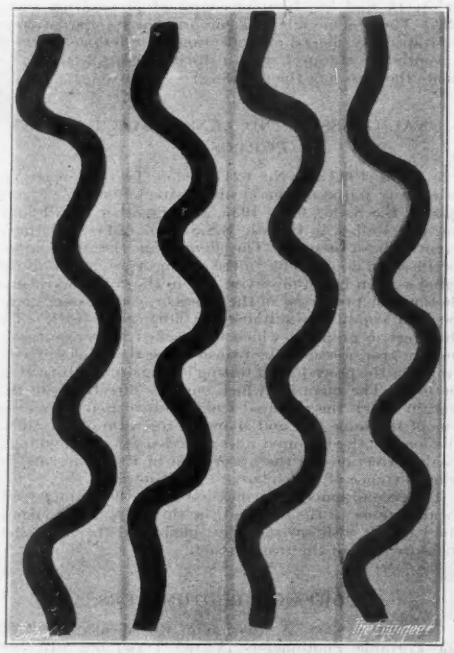


Fig. 3—Strips Cut from the Plane of Bending in a Creased Bend

the compression has raised the corrugation a desired amount, the press is stopped, the corrugation quenched, and the furnace moved on to form the adjoining corrugation. The first motion of the press in forming a corrugation causes an upsetting of the metal in the heated band before the swelling starts. This action accounts for the increased wall thickness to be found in the radial section through the crest of the corrugation. If a bend is to be formed, the bending is done after the corrugating process. The fabrication is followed by a suitable annealing heat treatment.

In forming a creased bend, the pipe is first filled with sand, locally heated at each crease in turn, and bent about 10 deg. at each crease. The creases thus bulge out from the original pipe wall and disappear at about two-thirds of the circumference of the pipe. This method of bending is said to have the advantage of permitting bending without a thinning of the wall on the outside of the bend and a thickening of the wall on the inside of the bend. Both corrugated and creased pipe may be made with much smaller radius bends than may be formed from corresponding smooth-walled tubing. The processes of manufacture are patented.

It is to be carefully noted that the method of manufacture results in each corrugation or crease being an individual with possibly different characteristics than its neighbours. Non-concentricity of the bore of the tubing with the outer surface may be serious if it provides a minimum section in the plane of maximum stress. Because of the localised stress conditions in these pipes, it is also highly important that no local defects, such as inclusions, laps, seams, or surface cracks appear in the tubing, because of the danger that one of these areas of weakness occur in a location of maximum stress.

Table I.—*Series A Pipes.*

Type Bend	Designation	Sketch	Dimensions R	A	B	C	D	Class Steel A.S.T.M. Spec. A-106-33T	Physical Properties Tensile Strength	Yield Point	Elongation % 1 in.	Elongation % 2 in.	Red. Area %	Chemical Analysis C	S	P	Mn	Si	Heat Treatment (see note)
Straight Tangent	AA			6'-8⅝"	6'-9⅛"			A	51,500	35,500	62	43	67						Normalized
	AB			6'-4⅛"	6'-8⅛"			A	51,650	34,350	62	42	68·4	0·13	0·024	0·011	0·53	0·01	Stress relieved
	AC			6'-5"	5'-8"			B	68,200	43,900	51	36	43·9	0·27	0·029	0·014	0·56	0·073	Normalized
Expansion U-bend	AD		1'-9"	6'-4⅞"	4'-1⅝"	4'-0¼"		A	58,000	35,350	64	43·5	63·1						Normalized
	AE		1'-9"	6'-6⅜"	4'-0½"	4'-0½"		B	70,000	43,000		36	46						Normalized
	AF		1'-9"	6'-6⅜"	4'-0½"	3'-11⅞"		A	56,700	38,100	64	43·5	65·9	0·16	0·022	0·015	0·54	0·10	Stress relieved
Quarter Bend with Tangents	AG		1'-9"	5'-3⅛"	5'-8½"			A	52,300	33,400	51	33	62·9	0·13	0·024	0·011	0·53	0·01	Normalized
	AH		1'-9"	5'-8⅝"	5'-3½"			A	51,600	37,200	68	48	72·6						Stress relieved
Straight Tangent (Plain Ends)	AJ			13'-10"	3'-4"			A	60,000	36,900		41·7							Stress relieved
	AK			13'-6½"	3'-4"			A	61,250	40,000		39							Stress relieved
	AL			13'-10"	3'-10"			A	61,500	42,000	60	41·5	61						Stress relieved
Single Offset Quarter Bend	AM		1'-4"	3'-11⅞"	2'-4"	1'-0¼"	1'-6⅛"	Special semi-corrugated bend 6·125" O.D. x 0·173" wall thickness											

All pipe - seamless steel tubing 6·625" O.D. x 0·280" wall thickness. Pitch of corrugations 2·5". Amplitude of corrugations 0·75".

Note - Heat treatment: Normalized 1575°F for 30 mins. cooled in air. Stress relieved 1200°F for 30 mins. cooled in furnace.

"The Engineer" ®

Experimental Methods: The Determination of the Endurance Limit of the Piping.

The Types of Testing Machines Used.—Two types of testing machine were used to determine the endurance properties of the pipes. One type of machine was designed to apply a specific stress to the specimen and the other type a specific strain.[15] The specific stress machine was, in principle, a large-scale model of the rotating beam fatigue testing machine frequently used in the laboratory for determining the endurance limit of small specimens. The specific strain machines were designed to subject the pipe to alternating flexure by applying a constant deflection to the specimen. A total of four machines of both types was built.

A view of the specific stress rotating beam testing machine is given in Fig. 4. Naturally only the long tangent specimens could be adapted to this apparatus. As will be seen, the long tangents were mounted in trunnion bearings at either end. Babbitt metal journals cast on the pipe carried collars which supported the desired deadweight load. The pipes were rotated by a motor and belt drive through a universal joint. With equal loads applied to the arms hanging from each collar, the bending moment across the corrugated section of the tangent was very nearly uniform. Hence all corrugations between the journals were subjected to approximately equal stress, and failure could reasonably be expected to occur in the weakest corrugation. With the pipe section at rest under load, the stress distribution in the pipe wall may be considered to be symmetrical with respect to a horizontal plane through the longitudinal neutral axis of the pipe. Now if the pipe is rotated 180 deg., the fibres which were in the top half-section under certain states of stress will acquire an equal value of stress, but with opposite sign. This same reasoning applies to the fibres originally in the bottom half-section. Thus for a complete revolution of the pipe each fibre passes through a complete stress cycle from a maximum positive value of stress through an equal minimum negative stress value back to the positive stress value. In this investigation the pipe rotative speeds ranged from 80 to 220 r.p.m. The speeds were carefully selected so that the pipe rotated smoothly and without vibration.

Table II.—*Series B Pipes.*

Type Bend	Designation	Sketch	Dimensions R	A	B	C	D	Class Steel A.S.T.M. Spec. A-106-33T	Physical Properties Tensile Strength	Yield Point	Elongation % 1 in.	Elongation % 2 in.	Red. Area %	Chemical Analysis C	S	P	Mn	Si	Heat Treatment (see note)
Straight Tangent	BA			6'-3¼"	6'-9⅝"			A	53,800	37,200	48·0	35·8	33·5						Stress relieved
	BB			6'-3⅛"	6'-11⅛"			A	53,800	37,200	48·0	35·8	33·5	0·14	0·029	0·012	0·29	0·01	Stress relieved
	BC			6'-4"	6'-10⅛"			A	53,800	37,200	48·0	35·8	33·5						Stress relieved
Quarter Bend with Tangents	BD		1'-3"	5'-3"	5'-3"			A	55,300	37,400	55·0	42·0	54·8						Stress relieved
	BE		1'-3"	5'-3"	5'-2⅞"			A	53,750	38,300	58·0	36·5	67·4						Stress relieved
	BF		1'-3"	5'-3"	5'-3"			A	53,750	38,300	58·0	36·5	67·4						Stress relieved
Straight Tangent (Plain Ends)	BG			13'-10"	3'-4"			A	61,100	42,100	61·0	41·0	63·4						Tempered
	BH			13'-10"	3'-4"			A	72,600	46,000		25·5	75·1	0·17	0·024	0·015	0·64	0·15	Tempered
	BJ			13'-10"	3'-4"			A	57,500	38,300	59·0	37·5	69·8						Stress relieved
Quarter Bend with Tangents	CA		1'-3"	5'-3"	5'-3"			A	59,900	41,900		41·0	66·1	0·16	0·022	0·015	0·64	0·15	Stress relieved
	CB		1'-3"	5'-3"	5'-3"			A	53,800	35,250		40·2	60·0						Stress relieved
	CC		1'-3"	5'-3"	5'-3"			A	56,500	40,000	60·0	39·0	61·7						Stress relieved
Expansion U-bend	CD		1'-3"	8'-5⅜"	8'-11⅞"	4'-0¼"	0'-11⅞"	A	63,000	42,100		32·8	68·6						Stress relieved
	CE		1'-3"	8'-6⅛"	8'-0¼"	4'-0¼"	1'-0"	A	60,000	43,700	59·0	42·0	66·9						Stress relieved
	CF		1'-3"	8'-6⅛"	8'-0"	4'-0"	1'-0⅛"	A	60,800	42,800	46·0	30·5	60·6						Stress relieved

All pipe - seamless steel tubing 6·625" O.D. x 0·288" wall thickness. Pitch of corrugations 2·5". Amplitude of corrugations 0·75". Pitch of creases 11" 15' Approx.

Note - Heat treatment: Stress relieved, heated to 1200°F for 10 mins. cooled in air. Tempered, heated to 1800°F quenched in water, reheated to 1200°F cooled in air.

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Two kinds of specific strain machines were developed. Views of these machines are given in Figs. 5 and 6. Two machines of the first kind were built. These machines each consisted of a 25 h.p. motor, driving through suitable reduction gearing, a shaft at right angles to the armature shaft extended. This driven shaft carried at either end an adjustable excentric upon which a journal was mounted. The excentrics could be adjusted to give the desired crank

* Dissertation submitted to the Advisory Board of the School of Engineering of the Johns Hopkins University for the degree of Doctor of Engineering.

[15] See "The Fatigue of Metals," by H. J. Gough (London), 1924. According to Gough's classification a specific stress testing machine is one which applies a definite load on the specimen for each cycle. The load remains constant throughout the test. A specific strain testing machine is one which produces a definite deformation of the specimen for each cycle. In this type the deformation remains constant throughout the test.

throw for the journal. This journal was connected through a vertical connecting-rod to a suitable point to apply load on the pipe section. The cycle frequency in these machines ranged from 30 to 90 cycles per minute.

The remaining specific strain type of machine was developed from the water end of a reciprocating pump. The pump was mounted with its rod horizontal and with a hydraulic system, under pressure, connected to either end of the pump cylinder. The water was alternately admitted to one end of the cylinder and discharged from the other through an arrangement of plug cocks whose action was governed by a linkage operated from an electric motor. With the apparatus in operation the pump rod would move back and forth at a cycle frequency of approximately 20 per minute. The amount of rod movement could be adjusted by suitable setting of the linkage mechanism to the plug cocks and could be positively limited by adjustable stops attached to one of the pump tie rods. The outer end of the pump rod was attached to a pipe flange for endurance testing purposes. This machine was used for testing certain expansion U-bends only.

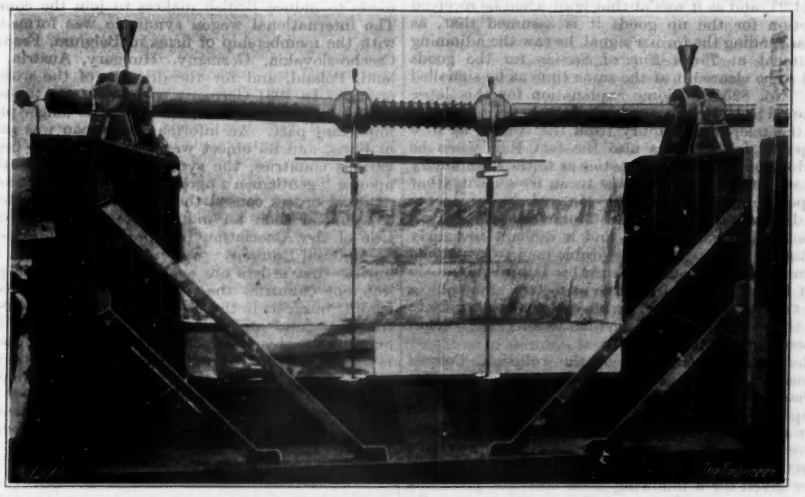


FIG. 4—ROTATING BEAM TESTING MACHINE

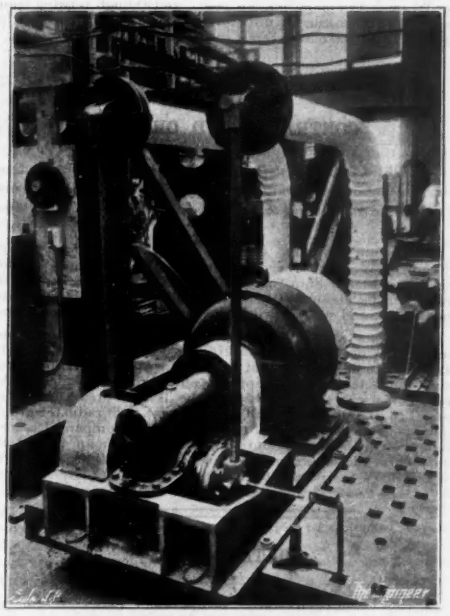


FIG. 5—QUARTER BENDS ERECTED FOR TEST ON SPECIFIC STRAIN TESTING MACHINE

Correlation of Results from Specific Stress and Specific Strain Fatigue Testing Machines.—In the specific stress type of fatigue testing machine the bending moment could be determined from the applied loading. The machine was equipped with an electrical device arranged so that if the pipe under test should begin to rotate excentrically or should fracture completely, the drive motor would stop. The time of actual failure—that is, when a fatigue crack developed completely through the pipe wall—was anticipated by a short period of slightly excentric rotation of the pipe before this excentricity became severe enough to signalise complete failure.

In the specific strain fatigue test the load-deflection characteristics of the pipes were first determined. The points of application of load and the direction in which the loads were applied corresponded to the conditions of loading of the specimens in the fatigue testing machine. With the load-deflection relationship established the bending moment and hence the nominal stress, as defined above, could be determined for a given deflection setting of the machine. The usual procedure in testing was first to select a desired value for the maximum nominal stress to be imposed in the pipe specimen, then to determine from the beam formula the load to be applied, and finally to set the fatigue testing machine to provide the corresponding deflection as established from the load-deflection curve for that specimen. As with the rotating beam specimens, the point of failure was taken to be when a fracture had occurred completely through the pipe wall. In order to assist in the detection of such a crack, the pipes were coated with whitewash before testing. No automatic means for stopping the machine at the time of failure could be devised. Hence close inspection of the pipes on the running tests was necessary.

It will be appreciated that, if yielding occurs as a fatigue crack develops, the actual load to maintain a constant deflection will be reduced in the specific strain type of machine. This reduction in applied load causes a proportional decrease in the applied stress which might tend to increase the time required for ultimate failure. Laboratory testing experience indicates, however, that fatigue cracks progress rapidly to failure when once started, and that close agreement in results may be expected in testing with specific stress and specific strain type machines.

The Effect of Range of Stress on Fatigue Strength.—When a material is subjected to cyclical variations of stress the range of stress is defined as the algebraic difference between the maximum and minimum stresses of the cycle. The range ratio is equal to the minimum stress divided by the maximum stress. Thus for the case of a completely reversed stress, or what is usually termed alternating stress, the range ratio is $-1{\cdot}0$. A range ratio of 0 would indicate that the stress varied from 0 to a maximum.

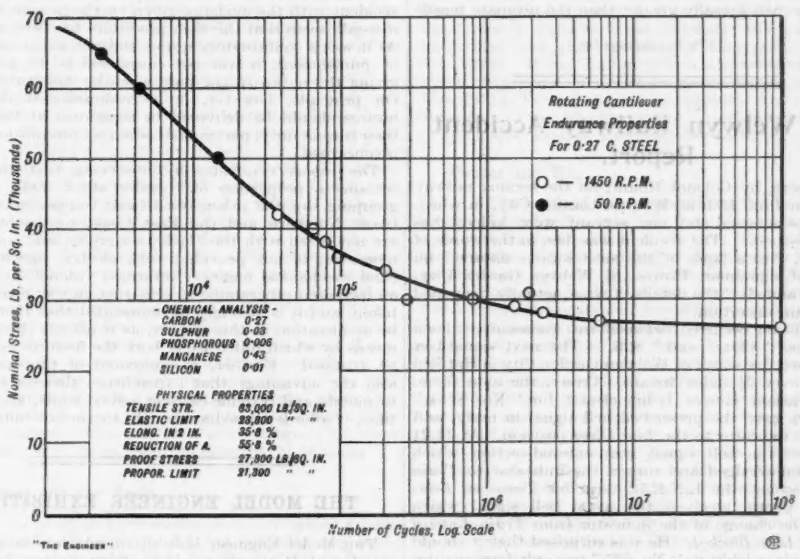


FIG. 7—FATIGUE GRAPH FOR A LOW CARBON STEEL

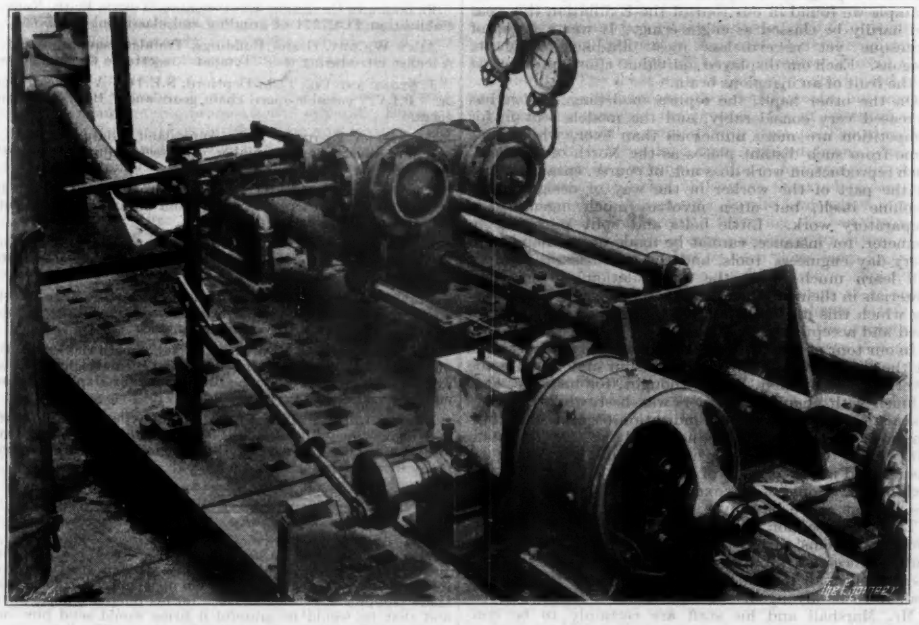


FIG. 6—PUMP-DRIVEN SPECIFIC STRAIN TESTING MACHINE

The range ratio can never have a value greater than 1.

Several investigators have developed formulæ and diagrams in order to define the relationship between stress range and fatigue strength. Gerber's parabola, Goodman's dynamic law, the formulæ of Launhardt and Weyrauch, and the formula developed by J. B. Johnson are perhaps the best known of the earlier work on the subject. Much of this work did not check particularly well with later experimental determinations. The Goodman diagram, for instance, implies that the endurance limit of a metal under alternating stress is one-third of the static ultimate tensile strength. This has been proven to be incorrect for many metals, particularly in the ferrous group. This diagram, however, further implies that the ratio between the endurance limit for a stress range from 0 to a maximum and the endurance limit for a complete reversal of stress is $1{\cdot}5$ to 1. This value was investigated by Professors Moore and Kommers, who concluded that it was a reasonably safe assumption for all metals.[16] They proposed a formula having the general form of the Johnson formula, but not based on any assumed ratio of endurance limit to ultimate static tensile strength and retaining the Goodman ratio of $1{\cdot}5$.

$$S_{max.} = \frac{3\,S_{-1}}{2-r}$$

where r is the range ratio, $S_{max.}$ is the maximum unit stress during a cycle, and S_{-1} is the endurance limit for alternating stress.

In the writer's investigation only two stress cycles were used; one a complete reversal of stress, and the other with stress varying from 0 to a maximum. In order to reduce the results of these tests to an equivalent basis to enable plotting failures associated with each of the two stress cycles to the same scale and on the same fatigue graph, the values of stress at failure in the case of the stress cycle from 0 to a maximum were divided by $1{\cdot}5$. This follows from the formula of Moore and Kommers.

The Relationship between Cycle Frequency and Endurance Limit.—The stress cycle frequency does not appear to have much, if any, effect on the fatigue resisting properties of metals. H. J. Gough summarises the results of various

[16] "The Fatigue of Metals," Chapter VII, by H. F. Moore and J. B. Kommers.

investigators in this field, who all concluded that no speed effect exists.[17] The cycle frequencies investigated varied from 150 to 5000 cycles per minute. The number of cycles of stress applied to a metal is said to be the controlling factor and the frequency of stress application is not significant. The case is very different when corrosive conditions are present together with the application of stress. The stress and corrosion have a mutually intensifying effect, but since corrosion may also proceed without simultaneously applied stressing, the total time of the action is of great importance. The effect of cycle frequency on corrosion fatigue is complex and depends upon many variables. This problem has been thoroughly studied by Dr. D. J. McAdam, jun., who investigated cases of variations of cyclic frequency of from 1 per day to 10,000 per minute.[18] It may be mentioned that the cases of the cycle frequency of 1 per day include a boiler explosion after approximately thirteen years' service.

Endurance Limit for the Steel from which the Piping Used was Fabricated.—It was not considered practicable to machine satisfactorily fatigue test specimens from the sample pipes used in this investigation. It is not necessary, however, to determine the actual endurance limit of this steel by direct test. It is generally accepted that a metal's endurance limit under cycles of reversed flexural stress may be expressed as a definite percentage of its ultimate tensile strength. No such correlation has been discovered between the endurance limit and any other physical property of a metal. The ratio of the endurance limit to the ultimate tensile strength has been termed the endurance ratio by Dr. McAdam, and for most steels will have a value ranging between 0·40 and 0·50. Fig. 7 gives a fatigue graph for a carbon steel whose composition was similar to the steel used in the pipe. This steel had a tensile strength of 63,000 lb. per square inch and an endurance limit of 27,000 lb. per square inch. The value of endurance ratio is hence 0·43. This value of endurance ratio has been applied to the observed tensile strength of the pipe steel in order to determine the value of its endurance limit.

In connection with Fig. 7 it may be stated that the three points of highest stress on the fatigue graph were determined at a specimen speed of 50 r.p.m., while the points for the remainder of the graph were determined at 1450 r.p.m. The point representing the highest stress on this graph was obtained with a computed bending stress on the specimen actually greater than the ultimate tensile strength.

(To be continued.)

The Welwyn Railway Accident Report.

THE report, by Colonel Mount, on the serious railway collision on June 15th at Welwyn Garden City, in which thirteen passengers and one servant were killed, has just been issued. The accident was due, in the words of the report, "to a lapse of the most serious nature" on the part of signalman Howes, of Welwyn Garden City, but, it is added, "the details of what actually happened must remain uncertain."

The collision occurred between two consecutive down trains, Nos. "825A" and "826." The next signal-box for the down line south of Welwyn Garden City is Hatfield N.3, just over 2½ miles distant. Crowe, the man there, at 11.20 asked Howes Is-line-clear? for "No. 825A," and Howes gave the prescribed bell signal in reply, and turned the indicator to the *Line Clear* position. At 11.21 Crowe sent the bell signal train-entered-section which Howes acknowledged and turned the indicator to *Train Entered Section*—the L.N.E.R. term for *Train on Line*. At 11.23 Crowe received the usual bell signal which precedes the change of the indicator from *Train Entered Section* to *Line Blocked*. He was surprised that it should have come so quickly, as "No. 825" was only four minutes in front, and thus "No. 825A" was likely to have had a signal check; moreover, it was a heavy train. He therefore telephoned Howes and asked "Is that out?" to which Howes replied "Yes." As there was no lapse of time between the bell signal and the telephone call, there was no necessity, Crowe maintained, to mention that he was referring to "No. 825A." "No. 826" was following immediately, so, according to Crowe's evidence, he, being satisfied that all was in order, asked Is-line-clear? for it. It was, he claimed, accepted in the usual way, and the train passed Crowe's box at 11.25 when that man sent the train-entering-section signal to Howes, who, so Crowe testified, then turned the indicator to *Train Entered Section*. Meanwhile, "No. 825A" had been checked on its way to Welwyn, not, as Crowe expected, owing to "No. 825" being in front—actually, "No. 825A" had been accepted by Welwyn North; but because—here we quote from Howes' evidence—he, Howe, was hindered by a telephone message from the station as to a parcel which delayed his pulling off the signals. Just as "No. 825A" was recovering from this signal slack it was caught up and run into by "No. 826." The driver of the latter train found all the signals at "clear." Colonel Mount does not think that there is any doubt as to Howes having sent train-out-of-section for "No. 825A" at 11.23 and having accepted "No. 826." There was a misunderstanding between the two men arising from Crowe's brief question and Howes' briefer answer. The use of the telephone in such a contingency as that may be necessary, but the form of the question and answer should be precise and quite definite, and Colonel Mount expresses regret, as Crowe himself did, that such an experienced and entirely reliable signalman as he is, was deceived by the assurance which he received from Howes.

It is evident from this that the section was cleared by Howes at 11.23, which was two minutes after "No. 825A" had passed Crowe and two minutes before it reached Howes. An explanation offered by the railway company is that Howes, when an up goods train passed him, sent "out-of-section" for that train to Crowe on the down line instrument instead of on the up line instrument to signalman Ball at Welwyn North box. It is significant that out-of-section for the goods train was not received by Ball until 11.27—four minutes later. Howes said that he did not send train-entering-section signal to Welwyn North nor out-of-section to Hatfield No. 3, because he was waiting to see its tail lamp. But there is no doubt that this signal was sent to Ball, as the latter says, at 11.27, and as it was at that hour when he received out-of-section for the up goods it is assumed that, as Howes was sending the former signal, he saw the adjoining up instrument at *Train Entered Section* for the goods train and so he cleared it at the same time as he signalled forward "No. 825A." Some explanation for this lapse may be found in Howes having been disturbed for a second time by the telephonic inquiry from the station as to a missing parcel. There was also the fact that when he went on duty he was handed a notice as to the disciplinary action it was proposed to take as to an irregularity that had happened a month earlier. He, moreover, is of a peculiar disposition, and Colonel Mount says: "In all the circumstances, therefore, I find it difficult to satisfy myself that Howes was really a suitable man to be serving in this important box, and I think his failure proves, in fact, that he was not." In a later place the same officer observes that in his opinion Howes was not really fit to shoulder the work, including the distractions and responsibility attaching to his post.

Considering the seriousness of the collision, Colonel Mount makes very few recommendations and all are of a simple character. Incidentally, it may be remarked that, as anticipated in our leading article of July 12th, he says that automatic train control would not have had a preventive effect. It is now a requirement that where a track circuit is provided at a home signal, *Line Clear* cannot be given for a following train until the preceding train has occupied and cleared the track circuit. By that the track circuit, 200 yards long, at the Welwyn Garden City home signal would have had to have been occupied and cleared by "No. 825A" before Howes could have accepted "No. 826." Telephonic conversations of the character in this instance should be formally phrased and duly recorded in the registers of each of the signalmen concerned and therefore open to supervision. The matter of the disciplinary notice prompts Colonel Mount to refer to a case he had to deal with at Stoke Works Junction in 1924. Comparing the report on that accident with the evidence given on the present occasion, it would seem that the then procedure has been modified. As it was a confirmatory notice and not a first intimation of punishment, it was not considered to be a case for giving the notice to the man when he was leaving duty. On principle, however, it is recommended that such notices should be delivered to signalmen at the end of their turn of duty, particularly when serious misdemeanour is concerned.

The report concludes by observing that there still remains a proportion of corridor stock built, prior to grouping, by the other constituent companies than the Great Northern and the East Coast companies, which are not fitted with the Buckeye coupler, and some of it, moreover, is not provided with electric lighting. The chief mechanical engineer informed Colonel Mount that an increased programme of construction was being undertaken, and it is strongly recommended that there should be acceleration in this respect, as it affords the principal means by which fuller use of both the features named can be attained. Further, re-equipment of this nature has also the advantage that expenditure thereon is related to mobile and revenue-earning assets, while, at the same time, it affords immediate benefit to various industries.

[17] See "The Fatigue of Metals," Chapter V, by H. J. Gough.

[18] "The Influence of Stress Range and Cycle Frequency on Corrosion," by D. J. McAdam, jun., "Proc." of A.S.T.M., 1930, Part II, Technical Papers.

THE MODEL ENGINEER EXHIBITION.

THE Model Engineer Exhibition, which is now open at the Royal Horticultural Hall, Westminster, but closes to-morrow evening (September 28th) has two of the characteristics of the chameleon—it is always changing and it is always bright. The Exhibition is now in its seventeenth year, and is as interesting as ever; but it has changed again. This year there is a notable absence of those unorthodox models, often made of the most crude materials, which have in the past been exhibited with the idea of demonstrating the maker's inventions. They have always fascinated us as an indication of the true inventive, progressive spirit, but practically the only example we found in our tour of the Exhibition this year can hardly be classed as engineering. It was a group of grotesque yet nevertheless most life-like marionette dragons. Each one displayed individual effort and all must be the fruit of an ingenious brain.

On the other hand, the replica modelling section has increased very considerably, and the models sent in for competition are more numerous than ever, while some come from such distant places as the North of Scotland. Such reproduction work does not, of course, entail thought on the part of the worker in the way of designing the machine itself, but often involves much ingenuity in preparatory work. Little bolts and split pins ⅛in. in diameter, for instance, cannot be made out of hand with every-day engineers' tools, and the enthusiastic amateur will learn much about the manipulation of tools and materials in their production. Another aspect of engineering which this model-making fosters is a familiarity with tried and accepted mechanisms.

In our tour of the Exhibition we had some conversations on the display of skill in workmanship and found some divergence of opinion. Some thought, for instance, that a finish with chamfered corners was best, while to others a sharp corner was the best indication of craftsmanship. Anyhow, the sharp corner is not nearly so easy to attain with hand tools, and its importance in training is exemplified in the display of the Royal Air Force at the Exhibition. Some of the examples of fitting work shown are as neat as we have ever seen.

The trade section is not, perhaps, quite so great as usual; it seems to have been swamped by the models. But a process of grouping has enabled a representative display of small machine and hand tools by the familiar makers to be arranged.

Mr. Marshall and his staff are certainly to be congratulated on the show.

THE INTERNATIONAL WAGON SYNDICATE.

A DEVELOPMENT of international relations in connection with the export trade in railway rolling stock, excluding locomotives, is reported to be proposed, and according to the Agence Economique et Financiére, efforts are being made to induce British makers to join the combination. The international wagon syndicate was formed in 1930 with the membership of firms in Belgium, France, Italy, Czecho-slovakia, Germany, Hungary, Austria, Switzerland, Poland, and for the division of the world export orders. In 1931 Germany withdrew from the syndicate, and since then the combination has no longer played any important part. An information bureau was maintained in Paris, and its object was also to mediate orders with various countries, the syndicate being practically based upon a "gentlemen's agreement." The absence of international orders caused the syndicate to become more of a technical than an industrial combination, under the title of the Association Internationale des Constructeurs de Material Roulant.

Now that orders are again beginning to be placed by different countries the idea has been conceived by the leading interests in the Association that it may be possible to revive and strengthen its activity as an industrial organisation by the inclusion of British works and the re-inclusion of the German makers. Negotiations for this purpose are stated by the Agence Economique to be proceeding with these groups, which are said to adopt no longer a negative attitude in the matter, and a conference for discussing the question is to be held at the end of this month.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. R. B. HODGSON is resigning his position as managing director of the Whessoe Foundry and Engineering Company, Ltd., Darlington, as at the end of September. He will be succeeded by Mr. C. M. Spielman, who has been an active director of the company for twelve years. Mr. Hodgson has been with the Whessoe Company for ten years, and though retiring from the position of managing director will remain a member of the board and still take an interest in the company's activities.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

ALEXANDER STEPHEN AND SONS, Ltd., Linthouse, Govan, Glasgow, S.W., have received an order to build a motor ship for the Union Steam Ship Company, of New Zealand, Ltd. The vessel will be about 284ft. long, will have a gross tonnage of about 3500, and will be driven by Stephen-Sulzer engines.

THE INTERNATIONAL MARINE RADIO COMPANY, Ltd., has received an order from John Holt and Co. (Liverpool), Ltd., Liverpool, to fit the vessels of their fleet with short and medium-wave radio telegraph equipment and direction finders. An order has also been received from the Temple Steamship Company, Ltd. (Lambert Bros., Ltd., managers), to fit radio telegraph equipment on the vessels of their fleet. The company has also secured against strong Continental competition an important contract for the supply and erection of a large radio coast station for the Black Sea port of Constantza.

CATALOGUES.

BRITISH INSULATED CABLES, Ltd., Prescot, Lancs.—Catalogue of feeder and distribution pillars and panels.

HADFIELDS, Ltd., Sheffield.—An illustrated brochure of the various classes of steel forgings made by the firm.

SIMMONDS ACCESSORIES, Ltd., Shell-Mex House, Strand, W.C.2.—Particulars of Simmonds "elastic stop nut."

WILLIAM BOBY AND CO., Ltd., 62–64, Brook-street, W.1.—Catalogue No. 173 on base-exchange water softeners.

STERNOL, Ltd., Royal London House, Finsbury-square, E.C.2.—A leaflet on "Protexon" film rust preventative.

FRASER AND CHALMERS ENGINEERING WORKS, Erith, Kent.—Publication FOC7274 of grinding and classifying machinery.

ALAN WRIGHT, Grand Buildings, Trafalgar-square, W.C.1.—A leaflet introducing the "Tempat" resettable thermal switch.

J. STONE AND CO., Ltd., Deptford, S.E.14.—A new catalogue on "P.I.V." variable-speed chain gears and "H.R." reduction gears.

GLENIFFER ENGINES, Ltd., Anniesland, Glasgow, W.A3.—brochure illustrating a number of vessels equipped with the firm's marine engines.

TRUE SCREWS, Ltd., 99, Clerkenwell-road, E.C.1.—1935 list of turned and rolled thread screws and nuts and general automatic repetition work.

SWITCHGEAR AND COWANS, Ltd., Elsinore-road, Old Trafford, Manchester.—Catalogue section No. 23–1 on duplicate bus-bar internal isolation switchgear.

FIRTH VICKERS STAINLESS STEELS, Ltd., Staybrite Works, Sheffield.—A booklet giving concise information on the manipulation of the firm's corrosion-resisting steels.

BIRMABRIGHT, Ltd., Dartmouth-road, Smethwick, near Birmingham.—A descriptive brochure of "Birmabright," the sea water resisting light alloy the firm makes for shipbuilding and marine engineering purposes.

THOMAS L. HALE (TIPTON), Ltd., Dudley Port, Tipton, Staffs.—A booklet on "Black Heart" malleable iron castings, which also gives a brief history of the iron industry, together with many interesting illustrations.

TRADE CATALOGUES AND PAMPHLETS.—Mr. W. A. Munford, Borough Librarian, Public Library, Biggin-street, Dover, informs us that he is anxious to build up a collection of the latest trade pamphlets, catalogues, &c., for his reference department, and that he would be grateful if firms would send him such material and add his name to their regular mailing lists.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Our Steel Trade with India.

India is an important market for British iron and steel material and machinery, and it is satisfactory to learn from the "Survey of the Import Trade of India" for the first three months of the current year that British exporters have more than held their own. In the case of electrical machinery, the total imports increased by about 40 per cent., and of the Rs. 51 lakhs at which this trade was valued, the British share was 34·5 lakhs. The imports of machinery and millwork aggregated a total of Rs. 327 lakhs, of which Rs. 217 lakhs, or 67 per cent., was with Great Britain. This included such commodities as railway locomotives, boilers, mining machinery (in which Great Britain replaced the United States as the principal country of supply), textile and sugar machinery. There was an increase in the value of oil-crushing and refining machinery from Rs. 5·1 lakhs to Rs. 9·6 lakhs, but in this case Germany benefited by increasing her exports to India from Rs. 1·6 lakhs to Rs. 4·1 lakhs. The share of the United Kingdom remained practically stationary at Rs. 2·2 lakhs. A noticeable reduction occurred in the imports of sugar-making machinery, and this, it is pointed out, reflected the arrest in the development of the local sugar industry, and indicated the extent to which it is nearing a production adequate to meet the total demand. The imports of this machinery for the first three months of 1934 were Rs. 14·3 lakhs; and Rs. 12·1 lakhs in 1935, as compared with Rs. 68 lakhs in the same period of 1933. In iron and steel British makers secured practically the whole trade in cast pipes, and fittings, sheets, and plates, sleepers, and more than 65 per cent. of the business in wrought tubes and fittings. The total import of steel bars in the three months under review was 11,614 tons, compared with 13,648 tons in the corresponding period of 1934. The value, however, was higher in 1935, owing to better prices having been obtained. The total imports of beams, channels, pillars, girders, and bridge work amounted to 5123 tons, the British share increasing from 2333 tons in the 1934 period, to 2969 tons during the first quarter of this year. The share of Belgium fell from 1375 tons to 965 tons, and of France from 557 tons to 4 tons. The arrivals from Germany, however, increased from 655 tons to 761 tons. There was a slight advance in the tonnage of galvanised sheets imported to 17,957 tons. Practically the whole of this trade was enjoyed by the United Kingdom, the imports advancing from 14,578 tons to 16,063 tons, whilst the Belgian share was 861 tons in the first quarter of 1934 and 1196 tons in the corresponding period of 1935. The imports from Japan, which were 866 tons for the first three months of last year, dropped to 653 tons for the first quarter of 1935. This booklet is published by H.M. Stationery Office.

The Pig Iron Market.

The chief feature of the pig iron market has been the steadiness of the demand. It might have been expected that with so many of the large consumers covered for months to come new business would have been scarce. Whilst this is the case to a certain extent, the orders reaching the producers from day to day amount to quite a satisfactory total. On the North-East Coast producers are in a position of considerable strength and have sold the greater part of their production beyond the end of the year. The makers appear to take the view that the production at the moment is sufficient to meet market requirements; but some of the consumers apparently fear that stringent conditions are developing and that the time is approaching when production should be increased. There has been some talk of an advance in prices, but this is not regarded as likely by the majority of consumers. In the Midlands buying has been rather quiet and has consisted principally of small parcels. The situation, nevertheless, is satisfactory, since specifications are reaching the producers with regularity and in some cases requests have been made for deliveries to be accelerated. The demand for pig iron of special grades from the engineering industry is steady and the improvement which took place recently has been maintained. The weak spot in the market is the poor demand for forge iron. In the Lancashire district steady rather than active conditions rule. Most of the big consumers have covered their needs and new business has been of a hand-to-mouth description. There are indications, however, that as the autumn advances consumers' requirements will expand. Business in pig iron in Scotland has developed no new feature. The demand from the light castings industry is strong and the autumn requirements look like being on a substantial scale. Business in hematite pig iron in all districts has been rather quiet, but so many consumers entered into big contracts a short time ago that this is not surprising. Recently the East Coast makers altered their price to Scottish consumers to 74s. delivered, but so far this has not resulted in much fresh business.

The North-East Coast and Yorkshire.

The iron and steel industry on the North-East Coast is working at high pressure, and it is expected that the total production at the end of the year will prove to be a new high record. The output of semi-finished steel in the shape of billets and sheet bars is unusually heavy and most of the works producing this material are operating at capacity. In some cases consumers are complaining that the makers are falling behind in deliveries, but although this may be so in a few cases, it is by no means general. The requirements of the shipyards on this coast, whilst they have expanded during recent weeks, are not heavy, but it is expected that a few more contracts for ships will be booked shortly, and this will be reflected in orders for the steel works. There has been no diminution in the demand for structural steel, and the constructional engineers are not only working on some big jobs, but they also have a fair amount of fresh work in view. Business in plates has been dull, and it is interesting to note that this is the only department in which Continental suppliers have had a difficulty in disposing of their quota. Lately a slight improvement has been noticeable, but most of the mills could do with more work. The demand for sheets also fails to show a permanent expansion. The home demand for medium thickness sheets is steady and good quantities are passing into consumption. Against this, however, buying by overseas markets is slow and severe competition is experienced. Some of the export markets lately have obtained considerable quantities of sheets from Germany by barter or on a "compensation" basis, and this is causing some concern to British exporters. The Yorkshire steel works are busy and at Sheffield several are operating at capacity. Some departments of the engineering industry are less well employed than a month or two ago, but, on the other hand, there is a growing demand for special steels. Business in stainless steel is active and the requirements of the market show no signs of diminishing.

The Midlands and South Wales.

The active conditions which have ruled in the Midlands for the greater part of this year show no signs of deteriorating. In certain departments a slight decline in business may be noticeable, but this has been made up by gains in other sections. A satisfactory development in the market in the last week or two has been the improved demand for plates. Business in this description of steel was poor for a long period and the recent flow of new orders has created a more cheerful feeling. Deliveries of structural steel are still heavy, although new buying has been rather quiet. This, however, is regarded as only a temporary lull, and it is anticipated that the constructional firms will shortly be in the market again, as most of them are well placed both as regards work in hand and fresh contracts in sight. The re-rolling mills are well employed, although the associated works continue to experience competition from the works which remain outside the organisation. Quotations are unaltered, the Association price being £8 12s. delivered less a rebate of 2s. 6d. to 5s., whilst the unassociated makers quote £7 12s. 6d. to £8 2s. 6d. according to quality. These prices, however, are subject to discussion when an attractive order is in question. Business in strip also is maintained at a high level, and is likely to continue so, as no offerings of Continental material are expected for some weeks. The black sheet industry is moderately well employed, but a vast proportion of the orders reaching the works is on home account and the export demand fails to develop signs of strength. Colliery requirements have been covered in a number of cases, but there has been a fair amount of new buying. Contracts, however, have been scarce and business has consisted largely of miscellaneous orders. Quotations are unaltered, roofing bars being quoted at £6 5s. to £7 10s., according to specification; whilst light arches are quoted at £8 5s. and heavy arches at £8 15s. In the South Wales market a steady improvement in business appears to be taking place. The constructional engineers are busy and are taking good supplies from the steel works, while ship repairers have a good deal of work to execute. The tin-plate market is firm and the latest returns show that the industry is working about 55 per cent. of capacity.

Scotland and the North.

The Scottish steel works have maintained a high rate of operation for some weeks, but sufficient new business has been obtained to take the place of the contracts which have been completed, and so far as can be seen the works are assured of being busily employed into the first quarter of next year. The demand has been comprehensive, in that it has covered most descriptions of steel; but the requirements of the constructional engineers, which have been a feature of the market for some time, show no indication of declining. The Government programme for increasing the Air Force and constructing aerodromes has contributed to the activity in this branch of the industry. Although a number of new orders have been secured by Clyde shipbuilders and a fair amount of steel is being absorbed by this industry, the total is not so heavy as in the first part of the year. General engineering firms, however, are taking larger supplies of steel than last month. The sheet makers have not experienced such an active demand as most other departments, but can see their way to maintain the present rate of operations, as the home demand continues fairly strong. The re-rolling industry, which for a long time suffered from a lack of orders, is now in a strong position; but complaints are heard of the competition of English firms which are not in the Association movement. In the Lancashire market business is gathering strength following the conclusion of the holiday season. The works producing structural steel are carrying sufficient orders to keep them busy for some months; but new buying has not been active. Specifications, however, are reaching the producers at a satisfactory rate. More interest has been shown lately in boiler and tank plates, but the position of the works producing these qualities might be better. There is a good demand for the lighter descriptions of steel and amongst the departments which are experiencing a steady request are the makers of bright-drawn steel bars, the official price for which is steady at £13 10s. In the Barrow district the steel works are busy. Rails, billets, bars, and slabs are being rolled at Workington and rails, hoops, and strip at Barrow.

Current Business.

Sir W. G. Armstrong Whitworth (Engineers), Ltd., of Newcastle, have received an order for fifteen locomotives from the Egyptian State Railways. Lithgows, Ltd., of Port Glasgow, have obtained an order from the Hain Steamship Company, London, for two cargo steamers of 9000 tons deadweight each. The engines will be built by David Rowan and Co., Glasgow. The North British Locomotive Company, Glasgow, have secured orders for a duplicate boiler for the Madras and Southern Mahratta Railway, two duplicate boilers for the Leopoldina Railway, and two locomotives for the San Paulo Railway. An order for 7000 tons of heavy steel rails for the South African Railways and Harbour Board has been divided between Dorman Long and Co., Middlesbrough, and the Cargo Fleet Iron Company, Middlesbrough. A Baltic States delegation representing Lithuania, Esthonia, and Latvia is touring the industrial centres of this country. An order for 3300 stair treads for the "Queen Mary" has been placed with James Brown and Son, Ltd., Brass Founders, of Middlesbrough. The Mid-Kent Water Company has placed a contract with the Mirrlees-Watson Company, Ltd., Glasgow, for a pumping plant set for the Newnham pumping station. T. W. Ward and Co., Ltd., Sheffield, has issued a circular to the effect that the plant at Palmer's Steel Works at Jarrow-on-Tyne is to be dismantled to make room for new equipment. The Department of Overseas Trade announces that the following contracts are open for tender:—South African Railways and Harbour Administration: Welded frame trailers, four and six-cylinder petrol-engined motor tractors, alternative quotations for compression-ignition-engined tractors, a number of sets of parts for portions of 3-ton animal wagons (the parts to consist of main frame only and brake gear and swivel pin), semi-trailer attachments for use with tractors of the mechanical horse type. Fore-carriages complete with all parts required for coupling automatically to the tractor, and also for the supply of all parts required on the trailer for transmitting the motion of the brake lever on the tractor to the trailer brake cross shaft (South Africa, November 4th, 1935); Union Tenders and Supplies Board: eleven oil-engine-driven generator sets (Pretoria, October 11th). Singapore, Municipal Water Department: Malleable iron pipe fittings and miscellaneous special fittings as required by the Water Department during the year 1936; galvanised unsocketed wrought iron gas and water tubes as required during the year 1936 (London or Singapore, November 4th, 1935). India, Indian Stores Department: Hard-drawn, high-conductivity bare solid copper conductors (New Delhi, November 5th). Argentina, Argentine State Oilfields: Two single-cylinder, double-acting motor pumping sets (Buenos Aires, October 14th).

Copper and Tin.

The demand for electrolytic copper in the United States has declined somewhat, but this is not surprising in view of the heavy sales which have been made during recent weeks. In the first half of September the sales by the producers are reported to have exceeded 70,000 short tons. There is no doubt that this tonnage is far in excess of the American consumers' immediate requirements, and that it represents a movement to lay in stocks. It is probable, therefore, that later in the year business will decline, but the producers should be left in a comfortable position as many consumers have contracted well into 1936. Lately, there have been reports that American copper companies are increasing production again, and this, of course, may change the position in the market if it is carried to any great length. There has been talk lately of another advance in the American domestic price, and prophecies that the quotation will stand at 12c. by the end of the year have been made; but when rumours of this description fly about it often means that the advance has reached its limit. European consumers have taken fair quantities of copper, but the financial position on the Continent prevents them obtaining their full requirements. American statistics give the stocks of refined copper at the end of August as 550,000 tons, a reduction of 21,000 tons on the month. The stocks in the United States are given as 249,000 tons. Prices in the London standard market have shown considerable firmness, but at times the advancing tendency has been checked by profit taking. The margin between the electrolytic and standard copper prices is now £5 per ton and appears to be gradually widening.... The main characteristics of the tin market remain unchanged. Prices have fluctuated somewhat and at times a weak tendency has developed in the forward position; but there is still a scarcity of prompt tin for market requirements and the backwardation, although it has lessened at times, has remained in the neighbourhood of £12. Buying by consumers seems to be at a rather low ebb at the moment, but it is suggested that direct sales by the producing interests may account for the apparent quietness of the industrial demand. Continental buying has been of a hand-to-mouth description, and seems to have been affected by the international situation. Shipments of tin on a large scale have been made to the United States, but some doubt is entertained as to whether this represents purchases by the American consumers or if it has been sent to that market to be sold.

The Lead Market.

The strong tone which recently developed in the lead market has been maintained and prices have advanced to the highest point reached since 1930. The expansion in demand which usually takes place in the autumn has made itself felt in this country, and at the same time reports from the Continent indicate an improvement in the industrial requirements of the chief consuming countries. In this market there seems to be no surplus supplies, and the market has probably been influenced by the continuation of the strike at the Mexican smelter. Fears have been expressed that this may lead to the development of tight conditions later in the year. Some lead has had to be taken out of warehouse in this country to satisfy Continental requirements, and arrivals of Empire lead are no more than sufficient to meet the home demand. In fact, the arrivals in this country have been used to fulfil old contracts, leaving little surplus for the market.

Current Prices for Metals and Fuels.

Makers' official home trade prices, per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 10 6	3 2 0
No. 1	3 11 0	3 3 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 10 0	3 4 0
No. 3 G.M.B.	3 7 6	3 1 6
No. 4 Forge	3 6 6	3 0 6
Basic (*Less 5/- rebate*)	3 10 0	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 11 0	—
„ „ Forge	3 6 6	—
Basic (*Less 5/- rebate*)	3 15 0	—
Northampton—		
Foundry No. 3	3 7 6	—
Forge	3 2 6	—
Derbyshire—		
No. 3 Foundry	3 11 0	—
Forge	3 6 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 13 6	—
No. 1 Foundry, ditto	3 12 6	—
No. 3 Foundry, ditto	3 10 0	—
Basic, d/d (*Less 5/- rebate*)	3 10 0	—
N.W. COAST—	3 14 0 d/d Glasgow	
Hematite Mixed Nos.	3 18 6 „ Sheffield	
	4 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
No. 3 quality	7 10 0	—
No. 4 „	8 0 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

LONDON AND THE SOUTH—	Home.	Export.
	£ s. d.	£ s. d.
Angles	8 10 0	7 7 6
Tees	9 10 0	8 7 6
Joists	8 17 6	7 7 6
Channels	8 15 6	7 12 6
Rounds, 3in. and up	9 10 0	8 7 6
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ¼in. (basis)	9 0 0	7 15 0
„ ⅜in.	9 5 0	8 0 0
„ ½in.	9 10 0	8 5 0
„ ⅝in.	9 15 0	8 10 0
„ ¾in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 5	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ ⅜in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ ⅝in.	9 10 0	8 10 0
„ ¾in.	9 5 0	8 5 0
Boiler Plates, ¼in.	9 5 0	—
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ ⅜in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ ⅝in.	9 12 6	8 10 0
„ ¾in.	9 7 6	8 5 0
Boiler Plates, ¼in.	9 7 6	7 15 0

STEEL (*continued*).

GLASGOW AND DISTRICT—	Home.	Export.
	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 6
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ ⅜in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ ⅝in.	9 10 0	8 10 0
„ ¾in.	9 5 0	8 5 0
Boiler Plates	9 5 0	—
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 7 6
Tees	9 7 6	8 7 6
Joists	8 15 0	7 7 0
Channels	8 12 6	7 12 6
Rounds, 3in. and up	9 7 6	8 7 6
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ ⅜in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ ⅝in.	9 12 6	8 10 0
„ ¾in.	9 10 0	8 5 0

IRELAND—	BELFAST.	REST OF IRELAND.
	£ s. d.	£ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ ⅜in.	9 5 0	9 7 6
„ ½in.	9 10 0	9 12 6
„ ⅝in.	9 15 0	9 17 6
„ ¾in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home.	Export.
Sheets.	£ s. d.	£ s. d.
10-G to 13-G., f.o.r.	9 10 0	8 15 0
14-G. to 20-G., d/d	10 15 0	9 0 0
21-G. to 24-G., d/d	11 0 0	9 5 0
25-G. to 27-G., d/d	11 12 6	9 17 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots, 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 0 0
2-ton to 4-ton lots	13 7 6
Under 2 tons	15 0 0

Export: £12 15s. 0d., c.i.f. India.
„ £11 5s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18/2.
Tin-plate Bars, d/d South Wales Works, £5 5s. 0d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 to 250 tons	5 17 6
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/- per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7/-
„ „ 6 p.c. to 8 p.c.	£21 0 0	7/-
„ „ 8 p.c. to 10 p.c.	£21 0 0	7/-
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£34 0 0	11/-
„ „ „ 1 p.c. carbon	£36 5 0	11/-
„ „ „ 0·50 p.c. carbon	£37 5 0	12/-
„ „ „ carbon free	9½d. per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose)	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/- p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/- p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/6 per lb.	

NON-FERROUS METALS.

Official Prices, September 25th.

COPPER—		
Cash	£34 16 3 to	£34 17 6
Three months	£35 2 6 to	£35 3 9
Electrolytic	£39 5 0 to	£39 15 0
Best Selected Ingots, d/d Birmingham	£39 5 0	
Sheets, Hot Rolled	£66 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	10½d.	10½d.
„ Brazed (basis)	10½d.	10½d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£31 0 0 to	£32 0 0
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	9½d.	9½d.
„ Brazed	11½d.	11½d.
TIN—		
Cash	£227 0 0 to	£230 0 0
Three months	£214 10 0 to	£215 0 0
LEAD: Cash and forward	£17 3 9	
SPELTER	£15 18 9 to	£16 0 0
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

LANARKSHIRE—	Export.
(f.o.b. Grangemouth)—Navigation Unscreened	13/3 to 13/6
„ Glasgow—Ell	15/-
„ „ Splint	17/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	12/- to 12/6
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	13/- to 14/-
Unscreened Navigation	13/3 to 13/6
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	13/3 to 13/6
Secondary Steam	12/- to 12/6

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	13/- to 16/-
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	13/9 to 14/3
„ Second	13/3 to 13/6
„ Best Small	10/6 to 11/-
Unscreened	12/6 to 13/6
DURHAM—	
Best Gas	14/8
Foundry Coke	19/- to 20 -

SHEFFIELD—	Inland.	
Best Hand-picked Branch	23/- to 25/-	—
South Yorkshire Best	20/- to 22/-	—
South Yorkshire Seconds	17/- to 18/-	—
Rough Slacks	8/- to 9/-	—
Nutty Slacks	7/- to 8/6	—

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	19/6
Best Seconds	19/- to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Bunker Smalls	12/6 to 13/6
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/- to 26/-
Foundry Coke	27/- to 40/-
Furnace Coke	19/- to 22/6
Patent Fuel	21/-
SWANSEA—	
Anthracite Coals:	
Best Large	36/- to 40/-
Machine-made Cobbles	41/- to 48/6
Nuts	40/- to 48/6
Beans	25/- to 30/-
Peas	19/- to 23/-
Rubbly Culm	11/- to 11/6
Steam Coals:	
Large Ordinary	18/- to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

French Engineering Notes.

(From our own Correspondent in Paris.)

The Economic Policy.

THE continuous decline of industrial activity and the absence of factors in the situation pointing to a recovery would appear to justify fully the plans set out by the Government for removing obstacles to foreign trade and adopting measures that may be expected to infuse more life into the economic system. Nothing now can be done that is not of an experimental character. But industrial interests will not accept experimental methods, and the committees which are inquiring into the possible effects of a suppression of import quotas are left in no doubt concerning the attitude of manufacturers and producers towards the proposal to remove what they regard as their only safeguard against dangerous foreign competition. Therefore the Government's plan to suppress quotas is held up temporarily in the hope that it will be possible to adopt some reciprocal arrangement of a more positive character, whereby risks to manufacturing and producing interests will be eliminated. The Minister of Commerce, Monsieur Bonnet, has returned to the idea of a general reciprocal agreement with a group of countries based upon a temporary stabilisation of currencies that will enable the French to open their market more freely to foreign trade, and as such an arrangement implies an international conference with interminable debates there is little prospect of a solution being reached in the early future. Meanwhile, the monthly foreign trade returns continue to show a decline of exchanges with an increasing adverse balance. There has been an augmentation of export tonnage which is accounted for by heavier consignments of iron ore, raw and semi steel, bounty fed wheat and other products of low value in relation to weight and the total values have considerably declined.

Shipbuilding.

When the Minister of the Merchant Marine arrived at Saint-Nazaire to embark upon the "Ville d'Alger," the first of the two fast ships for service between Marseilles and Algiers, which the State has subsidised and on which provision is made for auxiliary armament in time of hostilities, he received a delegation that urged upon him the necessity of taking steps to deal with the crisis that has overtaken the local shipyards, by putting new work in hand. It was stated that during the past two months unemployment had increased by 50 per cent. and that there was no prospect of further orders being received in the early future. There is still some activity in naval shipbuilding and the battleship "Strasbourg" will be put in hand almost immediately, but with the departure of the "Ville d'Alger" there are no more merchant ships on the stocks. The suggestion that an order for the new "Atlantique" should be given out cannot be entertained until the dispute with the insurance companies is definitely settled, and the delegation was particularly concerned in obtaining a promise that the work to be done on the "Normandie" during the winter months should be entrusted to Saint-Nazaire, which was threatened with the withdrawal of any further work on that ship in consequence of the strike that necessitated its final fitting out at Havre. The "Normandie" has again gone into dry dock at Havre for further inspection of the new propellers which replaced those used on her first voyages. Like other shipyards, Saint-Nazaire is suffering from the national economy cuts that affect particularly State subsidies, and until the country's finances are organised on a sound basis the Government is able to do little for the shipyards or for other departments of industrial activity.

Harbour Works.

In the programme of relief works an allocation of funds has been made for an extension of the breakwaters at Havre with a view to offering more complete protection to the outer port. Other ports are now endeavouring to secure financial assistance for the execution of works that have long been regarded as urgent and of others that had to be slowed down when Germany refused to continue supplying material on account of reparations. Calais is particularly anxious to carry out plans for the construction of a new outer port with a wharf 300 m. long and a depth of water at low tide of 10 m., as well as accommodation for the service of ferry boats between Calais and Dover. The new port is intended to create an industrial centre, as well as provide increased facilities for cross-Channel traffic. Boulogne and Marseilles have also been authorised to raise money for harbour extensions. The most important undertaking is the construction of the viaduct from La Pallice to a mole about midway between that port and the Ile de Rhé, where the deep channel is particularly safe and convenient for ships to land and embark passengers. The construction of the viaduct with a railway and roadway 1120 m. long and a mole 300 m. long has been suspended for a considerable time through financial difficulties, and efforts are now being made to carry the work through and complete a programme which is intended to make La Rochelle-La Pallice a port of call offering a direct route for ocean traffic to Paris. It competes with Bordeaux and the port of call at Verdon.

Naval Construction.

The submarine "Junon," which is the last of the series of four coast defence submarines under the 1930 instalment of the programme of naval construction, has been launched from the Augustin Normand shipyard. She has a length of 68·1 m., a width of 5·32 m., and a surface displacement of 597 tons. The two Vickers-Normand engines develop together 1300 h.p. The submarine has eight torpedo tubes and will be armed with a 75 mm. gun and a machine gun. The cruiser "Gloire," of 7720 tons, which was laid down in 1933, will be launched from the Chantiers de la Gironde at Bordeaux on September 28th. It is announced that the "Dunkerque" will leave the construction dock at Brest in January, and will then receive her eight 330 mm. guns, which will be mounted in two quadruple turrets forward.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

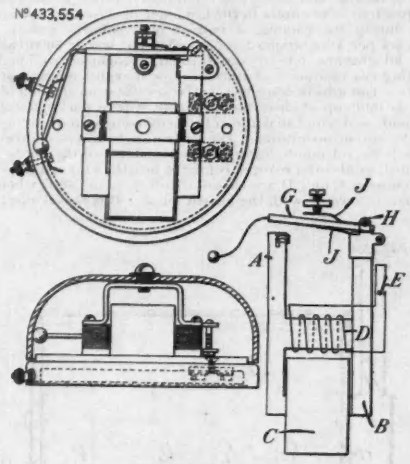
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

ELECTRICAL APPLIANCES.

433,554. February 16th, 1934.—ELECTRO-MAGNETIC BELLS AND RELAYS, Standard Telephones and Cables, Ltd., B. B. Grace, and R. St. George Terry, Connaught House, 63, Aldwych, London, W.C.2.

This is a bell for connection with an ordinary alternating house circuit and is said to make a continuous demand of only 1 volt-ampère, while the consumption, while it is ringing, may be six times as great, on a 200-250-volt supply. It is built up on inverted F-shaped laminations A and straight laminations B. The primary winding C is wound round one of the arms of the F

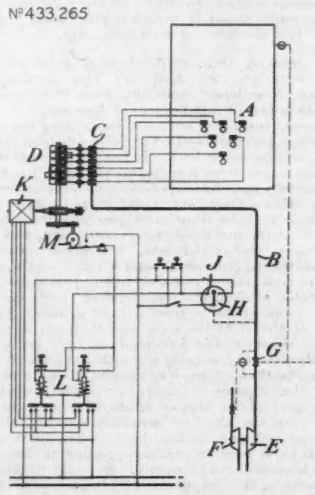


and the secondary D round the other. The primary is permanently connected with the house circuit and the secondary with a push button E. The armature G of the clapper is pivoted at H and is restrained by the springs J J. These springs are adjusted to the frequency of the supply. When the push button contacts are open the magnetic flux produced by the primary passes round the two arms of the F and does not affect the armature. With the contacts closed by the button the flux induced in the secondary opposes that of the primary and both fluxes pass up the laminations to the armature, which is vibrated in tune with the periodicity of the supply.—*April 16th*, 1935.

FURNACES.

433,265. February 13th, 1935.—THE AUTOMATIC SUPPLY OF POWDERED FUEL, Siemens-Schuckertwerke Aktiengesellschaft, Berlin-Siemensstadt, Germany.

This apparatus is intended to bring into service in a boiler furnace a number of burners appropriate to the load on the boiler, so that the burners may work at their best efficiency. The burners in the furnace are shown at A and are supplied from the pipe B through the control valves C. These valves are electro-magnetically operated by the drum controller D. The fuel is supplied by the pump E driven by the motor F. In the fuel supply pipe H there is a valve G which is opened or closed auto-

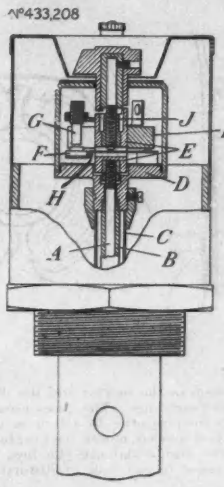


matically according to the load on the boiler. The differential pressure across this valve is used to control the motor F so that an adequate supply of fuel is delivered. If an increase in the supply of fuel raises the pressure in the pipe B above a predetermined maximum the pressure responsive device H actuates a switch to close the circuit J. This starts the motor K to revolve the controller D and bring into operation another burner. As this will result in a reduction of the pressure in the pipe B a holding-in circuit L is brought into action by the cam M. A reduction in the load on the boiler results in the cutting out of one or more of the burners in action.—*August 12th*, 1935.

LIGHTING AND HEATING.

433,208. February 8th, 1934.—ELECTRIC IMMERSION HEATERS, Ferranti Ltd., Hollinwood, Lancs.; and W. V. Butterfield.

This device is a thermostat for controlling the operation of immersion type electric heaters. It is pointed out that while such heaters are generally set to maintain a water temperature ranging between 160 deg. and 190 deg. Fah. for normal requirements a range between 98 deg. and 125 deg. is sufficient, and that radiation losses are then reduced. The thermostat takes the form of an Invar rod A in a brass tube B, which are attached to one another at the bottom. They are protected by a copper pocket C. At the top the brass tube carries the base-plate D and the Invar rod the insulating cap E. The heating current

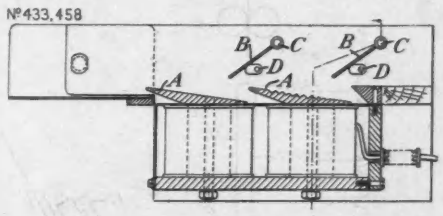


circuit is completed through the contacts F and G, one of which is attached to the insulating cap and the other is on the spring H fixed to the base-plate. A screw J provides means for setting the clearance between the contacts, which is, of course, also determined by the expansion and contraction of the thermo-couple. A magnet K is said to ensure a quick make and break of the contacts.—*August 8th*, 1935.

CRANES AND CONVEYORS.

433,458. February 9th, 1934.—ELECTRO-MAGNETIC SEPARATORS, Electromagnets, Ltd., 2, Church-street, Colmore-row, Birmingham, 3, and W. E. Box.

The object of this invention is to prevent magnetic particles which may ricochet from the poles of a magnetic separator from

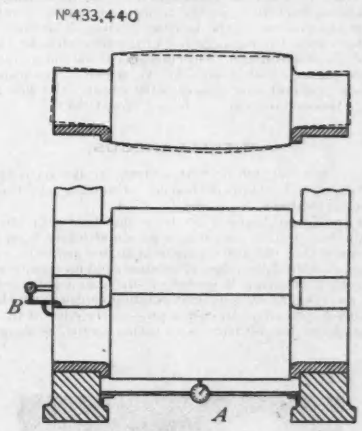


passing on to the outlet with the non-magnetic material. Above the poles A A of the separator there are arranged baffles B B pivoted to the framing at C C. The inclination of these baffles can be varied by the cams D D. They become magnetised by induction and are said to arrest any magnetic particles ricocheting from the main poles.—*August 9th*, 1935.

MACHINE TOOLS AND SHOP APPLIANCES.

433,440. April 9th, 1935.—ROLLING MILLS, P. Beretz, 122, Horst-Wesselstrasse, Stolberg, near Aachen, Germany.

When plate rolls are in service they must, of course, deflect under the rolling pressure, and are consequently made barrel-



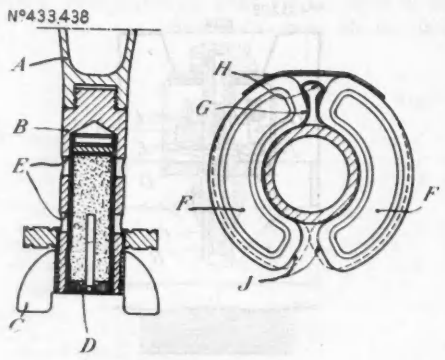
shaped so that when deflected the rolling part is straight. In order to determine the fact that this condition exists an indicator A is used beneath the centre of the bottom roll or above its journal, as at B, and the rolling pressure appropriately adjusted.—*August 14th*, 1935.

ORDNANCE AND ARMOUR.

433,438. April 1st, 1935.—PROJECTILES, E. W. Brandt, 101, Boulevard Murat, Paris, 16e, France.

This invention relates to propulsive cartridges for use in connection with mortar projectiles. In the embodiment shown, the body A of a projectile is prolonged, in the rearward direction, by a tail B on the extremity of which are mounted fins C. The propulsion is effected by the aid of a cartridge D, introduced and frictionally held in the tail B. Lateral openings E are provided in the tail to enable the gases to escape. In order to increase the range of the projectile, a variable number of propulsive relays, formed by a combustible casing, containing a supplementary charge, are disposed on the tail. These relays are constituted by two or more members F in the form of cylindrical crown segments, with rounded ends, resembling the shape of a bean, and connected together at one end G by an elastic

fitting or reinforcement H. The free edges J of each half of the relay diverge automatically on being pushed into contact with the tail, and then converge again due to the elastic action of the fitting H, when the whole is in position on the tail. The fins C prevent the relays from slipping backwards. The arrangement operates as follows :—The projectile with the cartridge, and the number of relays required for attaining the desired range,

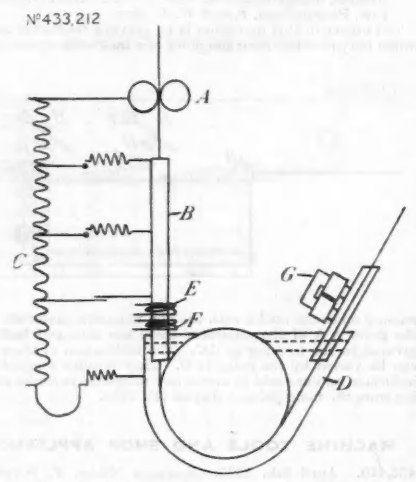


is placed in position in the mortar and the shot is fired by the percussion of the cartridge. The gases escaping through the openings E drive the projectile, by acting on its rear face. Since the relays have been placed, not on the fins, but in front thereof, their deflagration cannot damage the fins, which are consequently not exposed to any risk of distortion.—*August* 14*th*, 1935.

METALLURGY.

433,212. February 10th, 1934.—ELECTRICAL HEAT TREATMENT OF METALS, W. E. Burnand, 14, Oakholme-road, Sheffield, 10.

This apparatus is intended for heat-treating wire and strip. The wire, for instance, is fed in through the rolls A and passes through an electrically heated tubular furnace B. This furnace is heated by tappings from the secondary winding C of a transformer. The wire then dips into a mercury bath D, between which and the feed rolls there is also an electrical

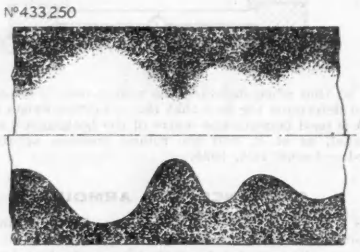


circuit, so that the wire is heated within itself. At the entry to the mercury bath there are two coils E and F surrounding the wire. One of these coils is energised by an alternating current and induces a current in the other coil which is utilised to regulate the current in the heating circuit. The inductance is dependent upon the temperature of the wire and the regulation thus becomes automatic. On emerging from the mercury bath the wire passes an electromagnet G, which is energised by an alternating current and consequently vibrates the wire to shake off any entrained mercury.—*August* 12*th*, 1935.

MISCELLANEOUS.

433,250. October 29th, 1934.—OPTICAL RECORDERS, N. V. Philips' Gloielampenfabriken, Emmasingel Eindhoven, North Brabant, Netherlands.

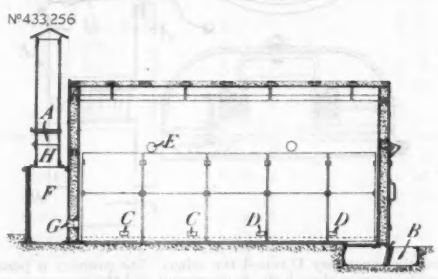
This invention appears to be connected with the optical reproduction of such phenomena as sound waves on a film. It is explained that the film may comprise, for instance, a celluloid backing, an adhesive surface of gelatine, and an opaque covering. This opaque covering is peeled off by a tool actuated by the sound waves and leaves a corresponding contour, which may be reproduced optically. In such a process the edge of the contour thus produced has hitherto been rather vague, as shown in the



upper part of the illustration, but with the emulsion suggested by the inventors a clearly defined edge is produced, as shown in the lower part. This effect is produced by the addition of a metal in a colloidal state. A mixture is suggested as follows :—An aqueous mercury sulphide sol containing from 4 to 5 grammes of mercury sulphide (HgS) and about 2 grammes of gelatine per 100 c.cm. of water is applied to a substratum comprising a gelatine layer at a temperature of about 40 deg. Cent. by means of a roller and the aggregate is then dried. In order to enable a satisfactory spreading of the solution during rolling, moistening means are preferably added to the colloid solution, careful watch being kept to see that the stability of the colloid system does not decrease. Thus, for example, the wetting agent known under the registered trade mark "Nekal" cannot be used, but the preparation "Alborit" may be used conveniently. "Nekal" is a substance consisting substantially of di-isopropylnaphthaline-β-sulphoacid and isomers. "Alborit" is a specimen of those substances which are prepared from gallic compounds and consists probably of sodium choleinate. These substances show the property of improving the spreading of gelatinous solutions, probably by decrease of surface tension. The gelatine of the sol serves as a protective colloid and thus has the advantage that the hydrogen sulphide (H_2S) which otherwise is necessary for the stabilisation of the HgS sol may be largely removed. In addition, the same gelatine serves in the covering layer as a binding agent. The covering power of mercury sulphide is high enough for allowing the covering layer to be thinner than two microns.—*August* 12*th*, 1935.

433,256. December 31st, 1934.—CARBONISING WOOD FOR OBTAINING CHARCOAL OF HIGH CALORIFIC VALUE, P. Guillaume, 187, Rue du Faubourg, Saint-Denis, Paris, France.

This invention has for its object a method of carbonising wood for obtaining wood charcoal of high calorific value, particularly to carbonising all creosoted wood, such as rejected railway sleepers. The gaseous hydrocarbons and heavy oil distillates of creosote and/or tar, suspended in the gaseous stream, released in the carbonising stage, which is extremely slow, are controlled in their movements and remain in contact as long as possible with the mass of wood, the part of the gases being held in reserve in a collector, and being again circulated through the mass of charcoal, so as to obtain in the last stage of the carbonisation, as also during the cooling, a fuel of high calorific value, 7500 calories per kilogramme for non-creosoted wood, 8000 calories per kilogramme for creosoted wood, recognised as ideal for feeding gas producers of stationary or movable motor installations. The kiln is described in the specification in some detail and is built up of sheet metal panels, with a packing of earth or sand, so devised that it can be easily transported and erected at the site of operations. The carbonising process is described as follows :—Upon lighting up, the register A of the flue is fully opened, as also the register B for the hearth, while all the vents or dampers C and D are closed. Half-an-hour later, when the hearth is burning well, the hearth register B is closed and those



of the dampers D, which are situated on either side of the door in proximity thereto, are partly opened, while the dampers C nearest to the flue are kept closed. From this moment the flue register A is progressively throttled. When it is considered suitable (by observing through the sight holes E) the flue register A is completely closed (so that the exit of gas collector F is closed) and the dampers D situated close to the door are completely opened. In this way the flow of the gases is reversed. The gaseous hydrocarbons freed in the stage of very slow carbonisation, and the distillates of heavy oil of creosote and/or of tar, in the state of suspension in the gaseous stream, remain in contact for the longest time possible with the mass of wood being carbonised are partly transformed into coke or else carried along into the collector F, stay therein and are again integrated in the mass of charcoal during the cooling of this mass. For this purpose the path of the gases has been arranged so that it terminates after passing through the flues G in the collector F, surmounted by the flue H through which the volatile gases alone escape (steam and hydrogen), while the heavier hydrocarbon gases and the distillates in suspension are held in reserve in this collector F and by means of the registers and flues which have been described are returned and combined in the mass of charcoal during the cooling of this mass. At the moment when the slow carbonisation is on the point of being completed, and for the subsequent cooling operation, all the registers and dampers are hermetically closed, a hermetic plug being applied to the lower part H of the flue.—*August* 12*th*, 1935.

433,257. January 18th, 1935.—LUBRICATING AND LIKE OILS AND GREASES, Standard Oil Development Company, Linden, New Jersey, and 100, West 10th-street, Wilmington, Delaware, United States of America.

This present invention relates to lubricating and like oils and greases, which are characterised by relatively high stability under high temperature conditions. It has been found that metallo-organic agents, such as lead tetra-ethyl and tin tetra-phenyl, are not the only ones which possess non-sludging properties, but there are others which are useful even to a greater degree. Among these may be mentioned generally the alkyl and aryl compounds of the metals of the second, third, and fifth groups of the periodic table of elements. The efficacy of the particular compounds for the purpose in hand depends on the constitution. It seems to be a general rule that in any particular group of the periodic table of elements the metal of the heavier molecular weight is more effective than a lighter metal, also that the elements of the right-hand or second group are more desirable than those of the left-hand or first group. Some of the metallo elements, notably bismuth and mercury, are usually more powerful than others, for example, arsenic and magnesium. However, the influence of the organic radical is of equal importance. In general the aryl or aromatic groups are much more desirable than the alkyl or paraffinic radicals, although both show activity to more or less degree. The most important of the metals to be used are mercury, cadmium, zinc, aluminium, thallium, bismuth, and antimony. As to the organic portion of the compounds, the simple alkyl hydrocarbon radicals may be used, such as ethyl, methyl, propyl, and butyl, whether straight chained or branch chained, and these are satisfactory particularly at high temperatures, say, 200 deg., 250 deg. Cent., and higher. The cyclic radicals, such as phenyl, naphthal, anthryl, are of much greater importance because they have a greater range of effectiveness both at low temperatures, 100 deg. to 150 deg. Cent., and high temperatures from 200 deg. to 250 deg. Cent. and up. The alkylated aromatic radicals, of which tolyl, alpha and beta normal or isopropyl-naphthyl, primary or secondary hexyl-naphthyl or anthryl compounds may be given as examples are especially desirable, but the aryl substituted aliphatics, such as diphenyl methane, are also satisfactory. While the exact nature of these various compounds and the mechanisms by which they improve the lubricating oil are not particularly understood, it is observed that all appear to show in greater or lesser degree the property of decreasing the sludging tendency of the oil, which means that decomposition products formed under their influence, whatever their nature, are for the most part freely soluble or, at least, dispersible in the oil, and that the tendency towards precipitation is thus greatly diminished.—*August* 12*th*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY AND SATURDAY, SEPT. 28TH.

SHIPPING, ENGINEERING AND MACHINERY EXHIBITION (INCORPORATING THE FOUNDRY TRADES EXHIBITION).—Olympia, London, W. Open 11 a.m. to 9 p.m. daily (except Sundays).

TUESDAY, OCT. 1ST.

BRITISH ASSOC. OF REFRIGERATION.—At Inst. of Marine Engineers, 85–88, Minories, E.C.3. Presidential address by Dr. F. A. Willcox. 6 p.m.

INST. OF AUTOMOBILE ENGINEERS.—At Royal Soc. of Arts, John-street, Adelphi, W.C.2. Presidential address, Mr. A. J. Hancock. 8 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "Measurement of Steel Corrosion," Dr. G. D. Bengough. 7.30 p.m.

THURSDAY, OCT. 3RD.

INST. OF MECHANICAL ENGINEERS: NORTH-WESTERN BRANCH.—Engineers' Club, Manchester. "Recent Developments in Hydraulic Couplings," Mr. H. Sinclair. 7.15 p.m.

INST. OF METALS.—James Watt Memorial Inst., Birmingham. "Gaseous and Solid Impurities in Ingots." Prof. J. H. Andrew. 7 p.m.

FRIDAY, OCT. 4TH.

INST. OF STRUCTURAL ENGINEERS: WESTERN COUNTIES BRANCH.—Merchant Venturers' Technical College, Bristol. Address by Dr. Oscar Faber. 7.15 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Short lectures: "Around the Royal Mint with a Note Book," Mr. H. W. L. Evans; "The Importance of Craftsmanship," Mr. W. H. Ballantyne; "Engineers and Economics," Dr. H. Chatley. 7.15 for 7.30 p.m.

KEIGHLEY ASSOC. OF ENGINEERS.—Kiosk Café, Keighley. Whist drive and social evening. 7.30 p.m.

SATURDAY, OCT. 5TH.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Visit to Foundry and Works at Daisyfield, Blackburn, of the British Northrop Loom Company. 2.15 p.m.

MONDAY, OCT. 7TH.

INST. OF MECHANICAL ENGINEERS: GRADUATES' SECTION.—Storey's-gate, St. James's Park, S.W.1. "Early Gearing," Mr. R. Wailes. 6.45 p.m.

INST. OF STRUCTURAL ENGINEERS: MIDLAND COUNTIES BRANCH, JUNIOR MEMBERS' SECTION.—James Watt Memorial Inst., Birmingham. Chairman's address, Mr. A. L. Percy. 6.30 p.m.

TUESDAY, OCT. 8TH.

ILLUMINATING ENGINEERING SOC.—At Lighting Service Bureau, 2, Savoy-hill, Strand, W.C.2. Presidential address, Mr. A. W. Beuttell; Exhibits, Demonstrations, and Report on Progress in Illuminating Engineering. 4.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—At Geisha Café, Hertford-street, Coventry. Presidential address, Mr. A. J. Hancock. 7.30 p.m.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Municipal College, Ormerod-road, Burnley. "Some Visits to Foundries in the U.S.A.," Mr. T. Makemson. 7.15 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow, C.2. Presidential Address, Prof. P. A. Hillhouse. 6 p.m.

INST. OF MARINE ENGINEERS.—85, The Minories, E.C.3. "The Testing of Engineering Materials," Dr. H. J. Gough and Mr. W. J. Clenshaw. 6 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. Extraordinary general meeting, 7 p.m. "Rolling of Steel," Mr. H. Williams. 7.30 p.m.

WEDNESDAY, OCT. 9TH.

INST. OF AUTOMOBILE ENGINEERS.—Metropole Hotel, Leeds. Presidential address, Mr. A. J. Hancock. 7.15 p.m.

INST. OF CHEMICAL ENGINEERS.—In Rooms of Chemical Soc., Burlington House, Piccadilly, W.1. "Modern Methods of Welding," Mr. C. H. Davy. 6 p.m.

INST. OF STRUCTURAL ENGINEERS: LANCASHIRE AND CHESHIRE BRANCH.—At Engineers' Club, Manchester. Chairman's address, Mr. W. B. McKay. 7 p.m.

THURSDAY, OCT. 10TH.

INST. OF AUTOMOBILE ENGINEERS.—At Merchant Venturers' Technical College, Bristol. Presidential address, Mr. A. J. Hancock. 7 p.m.

INST. OF MECHANICAL ENGINEERS: NORTH-WESTERN GRADUATES.—Engineers' Club, Manchester. Annual lecture, "Engineering Progress and Development," Mr. R. W. Bailey. 7.15 p.m.

INST. OF METALS: LONDON LOCAL SECTION.—In the Rooms of the Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W.1. Chairman's address, "Gases and Metals," Dr. C. J. Smithells. 7.30 p.m.

FRIDAY, OCT. 11TH.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, S.W.1. Informal meeting. Exhibition of films, with technical commentary, descriptive of the Vickers Works of the English Steel Corporation. 7 p.m.

INST. OF SANITARY ENGINEERS.—Chiltern Hall, Baker-street, W.1. Opening sessional meeting. 7.30 p.m.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Chairman's address, "Bleaching and Finishing of Cotton Cloth," Mr. H. P. Wright. 7.30 p.m.

RAILWAY CLUB.—At Royal Scottish Corporation Hall, Fetter-lane, E.C.4. "Some Famous British Railway Accidents," Mr. H. W. Bardsley. 7.30 p.m.

TUESDAY, OCT. 15TH.

ASSOC. OF SUPERVISING ELECTRICAL ENGINEERS.—At E.L.M.A. Lighting Service Bureau, 2, Savoy-hill, W.C.2. Presidential address. 7.15 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "The Testing of Steel Foundry Sands and its Practical Utility," Mr. T. R. Walker. 7.30 p.m.

WEDNESDAY, OCT. 16TH.

INST. OF STRUCTURAL ENGINEERS: SCOTTISH BRANCH.—At 129, Bath-street, Glasgow. Chairman's address, Mr. A. S. Kinnear. 7.15 p.m.

THURSDAY, OCT. 17TH.

INST. OF AUTOMOBILE ENGINEERS.—At the Park-lane Hotel, Piccadilly, W.1. Annual dinner. 7.30 for 8 p.m.

THURSDAY, OCT. 17TH, TO SATURDAY, OCT. 26TH.

SOCIETY OF MOTOR MANUFACTURERS AND TRADERS, LTD.—Twenty-ninth International Motor Exhibition, Olympia. Open daily (except Sundays).